# OFFICIAL PUBLICATIONS OF CORNELL UNIVERSITY

VOLUME VI NUMBER 4

# ANNOUNCEMENT OF THE SIBLEY COLLEGE OF MECHANICAL ENGINEERING AND THE MECHANIC ARTS 1915-16

FEBRUARY 1, 1915
PUBLISHED BY CORNELL UNIVERSITY
ITHACA, NEW YORK

Looking North toward the Quadrangle with Sibley College in the Distance

OFFICIAL PUBLICATIONS
OF CORNELL UNIVERSITY

VOLUME VI NUMBER 4

# ANNOUNCEMENT OF THE SIBLEY COLLEGE OF MECHANICAL ENGINEERING AND THE MECHANIC ARTS 1915-16

FEBRUARY 1, 1915
PUBLISHED BY CORNELL UNIVERSITY
ITHACA, NEW YORK

This announcement is intended to give detailed information to prospective students in the Sibley College of Mechanical Engineering and the Mechanic Arts of Cornell University.

For general information concerning the University and its various colleges, the requirements for admission, etc., the General Circular of Information should be consulted. This and the other Official Publications of Cornell University are listed on the last page of the cover of this pamphlet. Any one of the informational publications there mentioned will be sent gratis and post-free on application to The Secretary of Cornell University, Ithaca, N. Y.

## CALENDAR

### First Term, 1915–16

| | | |
|---|---|---|
| Sept. 17, | Friday, | Entrance examinations begin. |
| Sept. 27, | Monday, | Academic year begins. Registration of new students. Scholarship examinations begin. |
| Sept. 28, | Tuesday, | Registration of new students. |
| Sept. 29, | Wednesday, | Registration of old students. |
| Sept. 30, | Thursday, | Instruction begins. President's annual address to the students. |
| Oct. 2, | Saturday, | Registration, Graduate School. |
| Oct. 19, | Tuesday, | Last day for payment of tuition. |
| Nov. | | Thanksgiving recess. |
| Dec. 22, | Wednesday, | Instruction ends } Christmas Recess. |
| Jan. 5, | Wednesday, | Instruction resumed } |
| Jan. 11, | Tuesday, | Founder's Day. |
| Jan. 29, | Saturday, | Instruction ends. |
| Jan. 31, | Monday, | Term examinations begin. |

### Second Term, 1915–16

| | | |
|---|---|---|
| Feb. 12, | Saturday, | Registration, undergraduates. |
| Feb. 14, | Monday, | Registration, Graduate School. |
| Feb. 14, | Monday, | Instruction begins. |
| Mar. 3, | Friday, | Last day for payment of tuition. |
| April 5, | Wednesday, | Instruction ends } Spring Recess. |
| April 13, | Thursday, | Instruction resumed } |
| May 27, | Saturday, | Navy Day. |
| June 7, | Wednesday, | Term examinations begin. |
| June 21, | Wednesday, | Commencement. |

### First Term, 1916–17

| | | |
|---|---|---|
| Sept. 15, | Friday, | Entrance examinations begin. |
| Sept. 25, | Monday, | Academic year begins. Registration of new students. Scholarship examinations begin. |
| Sept. 26, | Tuesday, | Registration of new students. |
| Sept. 27, | Wednesday, | Registration of old students. |
| Sept. 28, | Thursday, | Instruction begins. President's annual address to the students. |

## INDEX

# CORNELL UNIVERSITY

Cornell University was incorporated under the laws of the State of New York on April 27, 1865, and was opened on October 7, 1868.

By the Morrill Land Grant Act (July 2, 1862), Congress granted to the several states certain public lands from the sale of which should be established at least one institution of higher learning in each state. By the act of April 27, 1865, the Legislature of New York State granted its share of these lands to the foundation of Cornell University.

To this combination of federal and state beneficence, Ezra Cornell added the resources of his own private fortune, and through his effort the University was established.

With the exception of the New York State Colleges of Agriculture and of Veterinary Medicine, which were founded and are supported almost entirely by the New York State Legislature with the aid of the federal government, the University in the main is supported by the income from the original endowment and from the funds donated subsequently by various benefactors.

The University is at Ithaca, New York, a city of fifteen thousand inhabitants, located at the south end of Cayuga Lake. The University Campus, lying high on the slope of the hills east of the town, commands a view of the western hills and of the valley and lake, which are of exceptional beauty.

The University, with an instructing staff numbering about 750, and a student enrollment of more than 5,000, is composed of the Graduate School (degrees A.M., M.M.E., Ph.D., etc.), and the following colleges:

The College of Arts and Sciences (degrees A.B., B.Chem.),

The College of Law (degree LL.B.),

The Medical College (degree M.D.),

The New York State Veterinary College (degree D.V.M.),

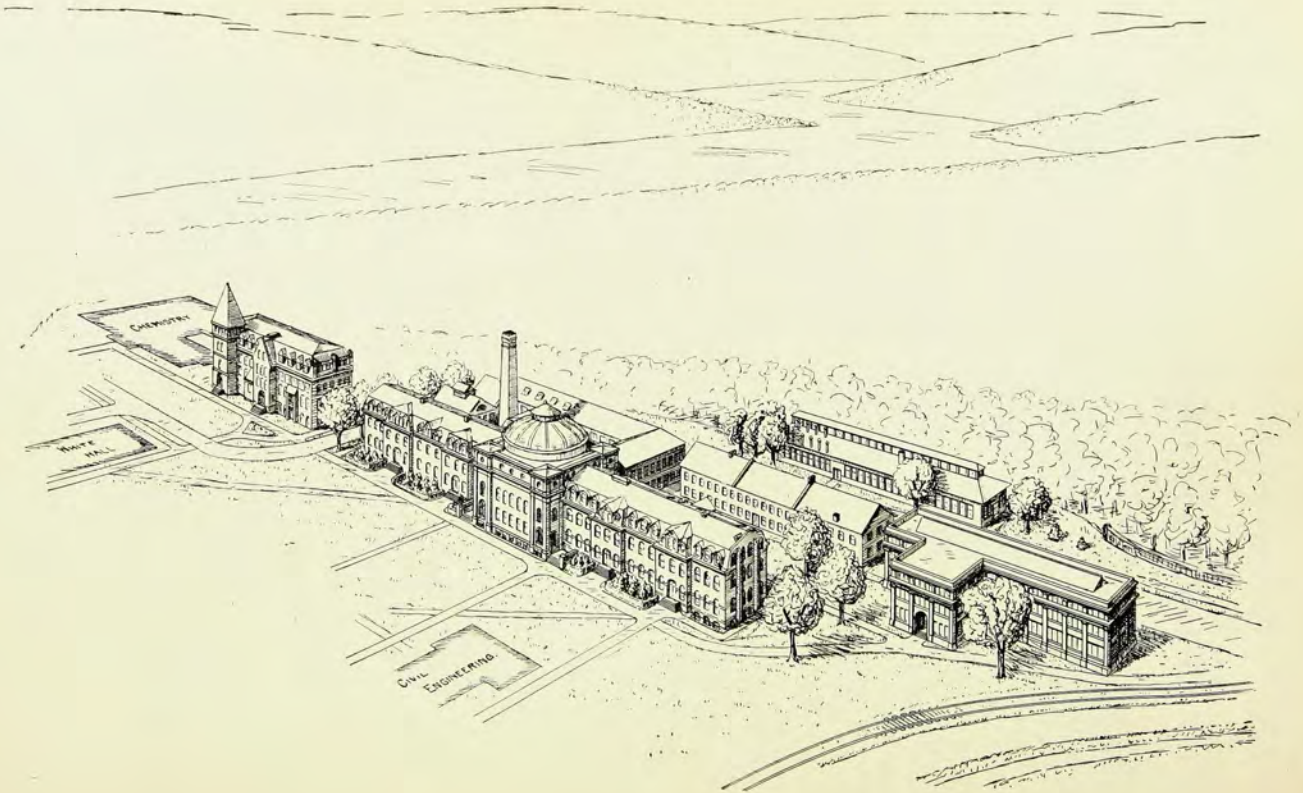
The New York State College of Agriculture (degree B.S.),

The College of Architecture (degree B.Arch.),

The College of Civil Engineering, including Hydraulics and Sanitary Engineering (degree C.E.),

The Sibley College of Mechanical Engineering and the Mechanic Arts, including branches of Mechanical, Electrical, Industrial and Mining Engineering (degree M.E.).

The students of the Sibley College of Mechanical Engineering, constituting nearly one-fifth of the total number in the University, are thus associated with the faculties and students of other colleges, and by this intellectual stimulus in many fields other than engineering, are broadened and given a clearer understanding of the relation of engineering to other human activities and interests.




Buildings of Sibley College

# SIBLEY COLLEGE OF MECHANICAL ENGINEERING AND THE MECHANIC ARTS

## FACULTY

Jacob Gould Schurman, A.M., D.Sc., LL.D., President.
Albert William Smith, B.M.E., M.M.E., Dean of the Faculty, and Professor of Power Engineering, in charge of the Department.
Rolla Clinton Carpenter, M.S., C.E., M.M.E., LL.D., Professor of Experimental Engineering, in charge of the Department of Engineering Research.
Dexter Simpson Kimball, A.B., M.E., Professor of Machine Design and Industrial Engineering, in charge of these Departments.
George Robert McDermott, Professor of Structural Design.
Herman Diederichs, M.E., Professor of Experimental Engineering, in charge of the Department.
William Nichols Barnard, M.E., Professor of Power Engineering, and Secretary of the College.
Vladimir Karapetoff, C.E., Professor of Electrical Engineering, acting as Professor in charge of the Department.
Clarence Floyd Hirshfeld, B.S., M.M.E., Professor of Power Engineering.
Howard Drysdale Hess, M.E., Professor of Machine Design.
Edgar Harper Wood, M.M.E., Professor of Mechanics of Engineering, in charge of the Department.
George Stanley Macomber, M.E., Assistant Professor of Electrical Engineering.
Calvin Dodge Albert, M.E., Assistant Professor of Machine Design.
Will Miller Sawdon, B.S., M.M.E., Assistant Professor of Experimental Engineering, assigned to the Department of Engineering Research.
Walter Stebbins Ford, M.E., Assistant Professor of Electrical Engineering.
George Burr Upton, M.M.E., Assistant Professor of Experimental Engineering.
Leslie David Hayes, M.E., Assistant Professor of Machine Design.
Seymour Stanton Garrett, C.E., Assistant Professor of Mechanics of Engineering.
Albert Edward Wells, Assistant Professor of Machine Construction, in charge of the Department.
Robert Long Daugherty, A.B., M.E., Assistant Professor of Hydraulics.
Frank Oakes Ellenwood, A.B., Assistant Professor of Power Engineering.
Victor Raymond Gage, M.E., Assistant Professor of Experimental Engineering.
Robertson Matthews, M.E., Assistant Professor of Power Engineering.
Clarence Walter Ham, M.E., Assistant Professor in Machine Design.
Henry Livingston Freeman, M.M.E., Instructor in Machine Design.
Frank Girard Tappan, A.M., M.E., Instructor in Electrical Engineering.
Daniel Robert Francis, E.E., B.A., Instructor in Mechanics of Engineering.
W. Rodney Cornell, B.Sc., Instructor in Mechanics of Engineering.
Arthur Graham Bierma, M.E., Instructor in Electrical Engineering.
Henry Mark Parmley, M.M.E., Instructor in Mechanics of Engineering.
Fred Edgar Klinck, M.E., Instructor in Experimental Engineering.
Myron A. Lee, M.M.E., Instructor in Machine Design.
Charles Dudley Corwin, M.E., Instructor in Machine Design.
Warren Howard Hook, M.E., Instructor in Experimental Engineering.
John George Pertsch, M.E., Instructor in Electrical Engineering.
Clarence Ellsworth Townsend, M.E., Instructor in Machine Design.
William Cyrus Ballard, M.E., Instructor in Electrical Engineering.
Clarence Andrew Peirce, A.B., M.E., Instructor in Power Engineering.
Paul Burns Eaton, M.E., Instructor in Machine Design.
Grover Cleveland Mills, B.M.E., Instructor in Machine Design.
Alexander Chilson Stevens, M.E., Instructor in Electrical Engineering.
Robert Franklin Chamberlain, M.E., Instructor in Electrical Engineering.
Robert Louis Stevenson, B.S. in E.E., Instructor in Electrical Engineering.
William Jacob Diederichs, M.E., Instructor in Experimental Engineering.

Ralph Burnette Day, M.E., Instructor in Mechanics of Engineering.
Harold Warner Brown, B.S., Instructor in Electrical Engineering.
Welles Goodspeed Catlin, M.E., Instructor in Electrical Engineering.
Thomas Ormond Hussey, M.E., Instructor in Machine Design.
Arnoud Jacob Joris van der Does de Bye, M.E., Instructor in Machine Design.
Edward Tompkins Jones, M.E., Instructor in Power Engineering.
Carrol Gardner Brown, B.S. in E.E., Instructor in Electrical Engineering.
Enoch Francis Garner, M.E., Instructor in Machine Design.
Roy Edward Clark, M.E., Instructor in Power Engineering.
Louis Jacquelin Bradford, B.S., Instructor in Machine Design.
Henry Hill Waters, M.E., Instructor in Machine Design.
Percy George McVetty, M.E., Instructor in Research Engineering.
Charles Harold Berry, M.E., Instructor in Power Engineering.
Robert William Graham, E.E., Instructor in Machine Design.
Charles Bigelow Bennett, E.E., Instructor in Machine Design.
William Albert Gibson, A.B., M.E., Instructor in Experimental Engineering.
William Deans, jr., M.E., Instructor in Electrical Engineering.
Adam Clark Davis, M.E., Instructor in Experimental Engineering.
Edgar Hutton Dix, jr., M.E., Instructor in Experimental Engineering.
James Lefferts Landt, M.E., Instructor in Experimental Engineering.
Charles Garret Thatcher, A.B., Instructor in Experimental Engineering.
Charles Edwin Thomas, M.E., Instructor in Experimental Engineering.
Paul Parrish Ashworth, M.E., Instructor in Machine Design.
Fred Stillman Rogers, M.E., Instructor in Machine Design.
E. Richard Page, B.S., Instructor in Electrical Engineering.
Francis Alley Hubbard, A.B., M.E.E., Instructor in Electrical Engineering.

### Assistants

James Eugene Vanderhoef, Foreman of Foundry.
Walter Liston Head, Foreman of Forge Shop.
Leroy Hooper, Foreman of Pattern Shop.
Birdette Newton Howe, Assistant in Machine Shop.
Howard Stanley Bush, Assistant in Pattern Shop.
Charles Albert Brooks, Assistant in Forge Shop.
William Benjamin Buck, Assistant in Machine Shop.
William Daniel McLaughlin, Assistant in Machine Shop.
——— ———, Assistant in Foundry.
Alfred W. Allen, Assistant in Pattern Shop.

George Washington Race, Mechanician in Sibley College.
Edward Warren Gregory, Mechanician.
Charles Alfred Culligan, Mechanician.
Charles Bedell, Engineer.

Margaret Isabelle Colquhoun, Clerk in Experimental Engineering.
Edith N. Robinson (Mrs.), Secretary to the Dean.

Paul Harold Berggreen, M.E., Librarian of Sibley College.

## PURPOSES OF INSTRUCTION

Sibley College is organized not only to teach the fundamental principles that underlie the various branches of mechanical, electrical and mining engineering, but also to give such practical training and such instruction in the economics of engineering as is possible in a technical school. In addition to giving this broad fundamental instruction, it is intended to prepare the student for entering one or more of the following special fields:*

A. **Electrical Engineering.**
B. **Heat-Power Engineering.** Steam Engineering or Internal Combustion Engineering.
C. **Structural and Plant Engineering.**
D. **Ship Design and Construction.**
E. **Industrial Engineering.**
F. **Mining Engineering.**

It is well recognized that theoretical instruction must be supplemented by experience in practice and by contact with life before one can attain his greatest usefulness in the profession; hence, in Sibley College, an effort is made to bring the student into contact with teachers who are closely in touch with commercial engineering practice to the end that he may thus become familiar with problems encountered in modern engineering and with commercial methods of solving them. It is hoped in this way to shorten somewhat the period of adjustment for the graduate when he begins actual engineering work.

The success of an engineer has come more and more to depend upon his ability to meet men of education and culture on equal terms. Since the work in the regular four year course in this college is almost wholly technical, it is preferable that the student before entering the College should have a thorough general education, and if possible, the training of a liberal college course. Those who have not had this broader education should, if possible, devote one or two years to subjects taught in the College of Arts and Sciences. A **five year course** for Sibley students, including the equivalent of one year of this broader training, is outlined on pages 31 and 32; and a **six year course** leading to the degrees of A.B. and M.E. is described on page 32. The entrance requirements for these courses demand less mathematical preparation than is specified for the four year engineering course.

In addition to the prescribed courses in Sibley College those students who have the necessary time available may elect, with the permission of their class adviser, any course in any college of the University, provided they have had the required preparation for the work.

### OPPORTUNITIES FOR EMPLOYMENT

**Mechanical Engineering** underlies nearly all branches of the industries; its province includes the design, construction, operation and testing of steam engines, steam turbines, boilers and power plant auxiliaries, gas and oil engines

*For branches relating to Civil Engineering and Architecture, see the Announcements of the College of Civil Engineering and of the College of Architecture.

with their auxiliaries, hydraulic machinery, pumping engines, railway equipment, compressed air machinery, ice making and refrigerating machinery, equipment for heating and ventilation, machine tools, mill equipment and transmission machinery. The work of the mechanical engineer includes the planning of power plants and factories, the selection and installation of their equipment, the development of the systems of operation and of manufacturing processes and the organization and administration of industries. **Electrical Engineering** includes the design, construction, operation and testing of electrical equipment used for the generation, transmission and utilization of electrical energy. Electrical engineering has many subdivisions such as power supply for factories, electric lighting, electric railways, telephony, telegraphy and electrical processes. **Mining Engineering** concerns itself with mining methods and machinery and the metallurgical processes.

From the foregoing very brief outline of some of the fields covered by the branches of engineering for which the students of Sibley College are fundamentally prepared, it is seen that the opportunities for the graduates to secure employment are extremely broad. The graduates, after gaining requisite experience in practice, usually occupy such positions as designers, supervisors of construction, inspectors, testers, research engineers, superintendents of departments, works managers, efficiency engineers, specialists in welfare work and in labor problems, consulting engineers, insurance investigators, commercial representatives, engineering salesmen, educators, and managers and presidents of commercial organizations.

There has always been a dearth of men fitted to fill the higher positions in the engineering and business fields; and the salary and position that the graduate will eventually obtain depends not only on his engineering training but on his inherent ability, industry, initiative, capacity to recognize and seize opportunities as they arise, and on his other personal qualities. The young man who has just graduated from Sibley College has little difficulty in securing immediate employment with salary sufficient for self-support, and if he eventually shows the proper qualifications he may rise to the highest positions attainable in engineering and business fields.

## BUILDINGS AND EQUIPMENT OF SIBLEY COLLEGE

The Sibley College of Mechanical Engineering and the Mechanic Arts receives its name from the late Hiram Sibley of Rochester, who between the years 1870 and 1887, gave $180,000 toward its endowment and equipment. Mr. Hiram W. Sibley has added more than $150,000 for later constructions and equipment. The Sibley buildings are situated at the north end of the Campus, and stand upon ground leased from the University for the purposes of the College, under an agreement with the late Hiram Sibley. There are six large buildings and several smaller ones.

The main building is three hundred and seventy feet long, fifty feet in width, and three stories in height. It contains the reading room and reference library, drawing rooms, lecture rooms, offices, class rooms, and a large and well-lighted auditorium.

Franklin Hall is occupied on its first two floors by the Department of Electrical Engineering, which in addition uses temporarily a portion of Rand Hall.

The Department of Experimental Engineering occupies two two-story buildings, each about one hundred and fifty feet long by forty feet wide, besides a boiler plant thirty by forty feet, a refrigeration laboratory thirty by forty feet, and the east basement of the main building.

Rand Hall has recently been added to the Sibley College group (at a cost of $60,000) through the generosity of Mrs. Florence O. R. Lang. This building is a memorial to Jasper R. Rand, Addison C. Rand, and Jasper R. Rand, jr., the father, uncle, and brother of the donor. It is a three-story building, the main portion of which is one hundred and seventy feet long and fifty feet wide; it contains the machine shop and pattern shop, and a portion is used temporarily for the electrical laboratories.

The foundry and forge shops occupy a one-story building one hundred and eighty feet long and forty feet wide.

## MECHANICAL LABORATORIES

The instruction in the Department of Experimental Engineering is given in several separate laboratories, each of which is thoroughly equipped with the machines, apparatus, and instruments necessary for instruction in research.

**The Materials Testing Laboratory.** This laboratory is equipped for tension and compression tests with an Olsen 300,000 pound machine, a Riehlé 100,000 pound machine, a 200,000 pound Emery hydraulic machine, together with several other machines varying in capacity from 10,000 to 100,000 pounds. For transverse tests there is a Riehlé machine of 200,000 pounds capacity and a Fairbanks machine of 10,000 pounds capacity. There are two Thurston autographic torsion machines, one Olsen torsion machine of 200,000 inch-pounds capacity, and one Upton-Lewis fatigue testing machine. The equipment includes extensometers, a cathetometer, gas furnaces, tempering baths, and all other apparatus required for the determination of the physical qualities of engineering materials under tensile, compressive, transverse, and torsional stress, and under different kinds of heat treatment.

**The Steam Laboratory.** In this laboratory there is a 150 H.P. triple expansion Allis-Corliss engine so fitted up that it may be operated as a simple, compound, or triple expansion engine, condensing or non-condensing. There are also several smaller engines including a Russell, a Harris-Corliss, a Payne, a Troy, and a Wickes Bros. automatic engine. There are three surface condensers which may be connected with these engines as desired. There is a 35 kw horizontal Curtis turbine and a 15 kw De Laval turbine which drive electric generators and may be run condensing or non-condensing.

A two-stage steam-driven Ingersoll-Rand compressor and three air-brake pumps of different types, together with meters, nozzles, and other instruments, are used for routine tests. This part of the laboratory also has several fans that can be arranged and equipped for testing.

The apparatus and instruments used for engine testing comprise about 80 indicators of different types, about 75 steam gauges, a number of calorimeters for the determination of the quality of steam, speed counters, tachometers, planimeters, etc., besides a number of dynamometers of various kinds.

The boiler section of this laboratory has one 150 H. P. Babcock & Wilcox water-tube boiler of the marine type, and one 100 H. P. Babcock & Wilcox water-

tube boiler of the standard type, both of which are fitted with internal superheaters. There is also one 80 H. P. Heine water-tube boiler and one 25 H. P. Roberts safety boiler connected with a Foster independent superheater. The auxiliary apparatus consists of a Cochrane open heater, a Wainwright closed heater, steam pumps, traps, injectors, etc. A full set of scales, measuring tanks, gauges, flue gas apparatus, separating and throttling calorimeters, pyrometers, etc., complete the boiler equipment.

**The Gas Engine Laboratory.** The equipment consists of an 8 H. P. Westinghouse gas engine, an 8 H. P. Olds gasoline engine, an 8 H. P. Fairbanks gasoline engine, a 6 H. P. "Ingeco" oil engine, a 6 H. P. Hornsby-Akroyd oil engine, a 15 H. P. Hornsby-Akroyd oil engine, a 16 H. P. Acme gas engine run on producer gas from a 15 H. P. suction gas-producer, and a 30 H. P. three-cylinder Westinghouse gas engine with gas producer. This last engine may also be operated with illuminating gas. Hot air engines are represented by a Rider and an Ericsson engine. This engine equipment is chosen to give as great a variety as possible in the fuels used, types of governing, etc.

The supply of testing instruments includes several outside-spring indicators, optical indicators, and a manograph. For temperature measurements there are available high-reading thermometers and pyrometers of the expansion and electrical types.

**The Hydraulic Laboratory.** This laboratory contains the following machines and apparatus: a 6-inch single stage De Laval centrifugal pump; a 2½ inch two-stage Worthington centrifugal pump; a 12-inch Doble water wheel; a 10-inch Trump turbine; several Pelton wheels and hydraulic rams; sets of weir boxes with various types of weirs and nozzles for the determination of coefficients of discharge; various types of water meters and other apparatus for measuring the flow of water, such as Pitot tubes, Venturi meters, current meters, etc.

**The Oil Testing Laboratory.** This laboratory contains a Cornell oil-testing machine, a Thurston standard railway-testing machine, and several smaller Thurston machines. The rest of the equipment consists of several viscosimeters of different types, together with the necessary hydrometers and thermometers.

**The Refrigeration Laboratory.** For the study of refrigeration the mechanical laboratory possesses a very complete York refrigerating plant having a capacity of 15 tons of ice, besides a Brunswick and a De La Vergne machine of small size.

**The Cement Laboratory.** This laboratory not only contains the ordinary apparatus for the testing of cement and concrete, but in addition is equipped with crushing and grinding machinery and a small vertical kiln for making investigations on the manufacture of cement from raw material.

**The Fuel Testing Laboratory.** This laboratory contains a complete equipment of fuel calorimeters, and other apparatus needed for the determination of the composition and calorific value of fuel, whether gaseous, liquid, or solid.

## THE ELECTRICAL EQUIPMENT

The Department of Electrical Engineering is fully equipped with modern apparatus for experimental lectures, laboratory practice, plant testing, standardizing of instruments, and investigation. This apparatus has been selected primarily to exemplify modern shop tests and to familiarize the student with the practical apparatus as well as with the theory of operation of electrical devices.

**The Lecture Equipment.** In addition to the usual complement of apparatus for demonstration, the lecture equipment includes an air-insulated, high-pressure transformer with necessary regulators for subjecting insulators and insulating material to alternating pressures up to 60,000 volts. This can be supplemented by additional transformers for raising the pressure still higher. A 30,000 volt transformer provides current for wireless telegraphy. All the standard equipment, as well as many pieces of specially designed apparatus, is employed to illustrate the operation of the principal laws applied in electrical engineering. Exhibits of apparatus, such as street railway car controllers, rail sections, insulating and line material, etc., are provided in profusion. This list includes a complete outfit for exhibiting in actual operation the multiple system of electric car control. An electric elevator and an overhead traveling crane system permit the laboratory motors and generators to be brought into the lecture room and class room for purposes of operation and illustration.

In order to bring the demonstration apparatus nearer to the beginner, a special room is provided with simple electrical devices with which the student may readily experiment. The equipment is changed every few weeks to correspond with the topics which are being studied in class.

**The Laboratories.** The laboratory apparatus comprises a full complement of modern alternating and direct-current machinery of all kinds. The alternating-current equipment includes single and polyphase alternators and synchronous motors, induction motors, transformers, and all apparatus auxiliary thereto. A variety of direct-current dynamos and motors, suitably mounted for testing, cover the field of direct current machinery. There is a large supply of ammeters, voltmeters, and wattmeters of all types and ranges. A General Electric oscillograph is available for determining wave forms of alternating currents and voltages. A 500-cycle alternator is provided for experiments on electric resonance and in wireless telegraphy. A De Laval steam turbine geared to a direct-current generator, a direct-connected marine set, circuit breakers, switches, water rheostats, and other auxiliaries are in use for plant test experiments. A 35 kw direct-connected turbo-generator is also available. The plant testing is done largely outside of the college buildings and for this purpose a large variety of ammeters, voltmeters, wattmeters, and other instruments are maintained in adjustment. Special facilities are provided for the standardization of all electrical apparatus. Board of Trade and Reichsanstalt standards of resistance with large current-carrying capacity, potentiometers and galvanometers, and reference standards of electro-motive force are among the facilities provided for this purpose. In addition to the apparatus in the laboratories, the students may observe in operation a three-phase power transmission in the local power and lighting service. Large direct-connected generators, rotaries, constant current regulators and induction motors, as well as the lighting and railway system, are convenient for inspection. The University has a modern hydro-electric plant containing large three-phase alternators direct-driven by Doble impulse water-wheels and by a reaction turbine. The power station also contains smaller units for direct-current supply with all necessary auxiliary apparatus.

### ENGINEERING RESEARCH EQUIPMENT

The Department of Engineering Research has all the equipment and resources of the various departments of Sibley College available for use in connection with its investigations. It is also possible, in most instances, to arrange to use the engineering and scientific equipment of the other Colleges of the University.

### WORK SHOPS

The foundry occupies floor space of about 4800 square feet, and has an equipment for the production of iron and composition castings. The methods of producing duplicate work are demonstrated by moulding machines of different types selected to illustrate the production of castings of various kinds at lowest labor cost.

The forge shop has the usual equipment of standard forges and small tools, as well as a modern drop-forge plant. Forging by the drop-hammer method, and power press work are demonstrated and discussed.

The pattern shop occupies the top floor of Rand Hall with floor space of 8,440 square feet. The work given the students in this department includes the use of hand and power operated tools under instructors who are skilled in the trade of pattern making.

The machine shop is located on the ground floor of Rand Hall with the same floor area as the pattern shop. It is equipped with an electric traveling crane and representative modern machine tools selected with a view of demonstrating manufacturing methods. A part of the work-shop equipment is installed to illustrate the latest practice in production with specialized labor-saving machinery. The students are not expected to become skilled operators of the machines of this class, but to acquire a general knowledge of their possibilities in the kinds of work to which they are adapted. The equipment is arranged in groups, each under the charge of an instructor who has made a special study of the machinery in his group.

### ENGINEERING LIBRARY

The Library of Sibley College, which is a branch of the University Library, contains a splendid equipment of reference books and periodical literature relating to the fields of engineering taught in Sibley College and to the allied branches of learning. In addition to this library the student has access to the University Library and to the special libraries of the other Colleges and departments of the University.

## SCHOLARSHIPS, PRIZES AND LOANS

A special pamphlet on prizes may be secured from the Secretary of the University. A description of the scholarships open to entering freshmen in all colleges is given in the General Circular of Information. Regarding Graduate Scholarships, Fellowships, etc., see the Announcement of the Graduate School.

The attention of Sibley students is directed particularly to the following paragraphs:—

**The Frank William Padgham Scholarship.** This scholarship, founded in 1892 by Amos Padgham of Syracuse, New York, in memory of his son, Frank William Padgham, a graduate of Sibley College of the class of 1888, entitles the

holder to free tuition and fees in the regular course in Sibley College of Mechanical Engineering. It cannot be held in connection with a New York State Scholarship. The Frank William Padgham Scholarship will be awarded to the candidate who has had his preparatory education wholly or in part in the public schools of Syracuse, New York, and who, having been admitted to the regular course in Sibley College, shall pass the best examination in a competitive examination on the following studies selected from those that may be offered for admission to Sibley College: 1. solid geometry; advanced algebra; plane trigonometry; 2. third year German; 3. third year French; 4. English. Of these subjects the candidate must take three including mathematics. The examination for the Padgham Scholarship is held at the same time as the University Undergraduate Scholarship examinations; it is, however, a special examination and the candidate must declare his intention to enter the Padgham Scholarship examination and state his qualifications therefor to the Registrar, who will issue the usual permit to enter the examination. In case no one qualifies for this scholarship in the foregoing manner, the Faculty of Sibley College may, with certain restrictions, recommend the awarding of the scholarship to some worthy applicant, preferably one from Syracuse. Upon request, detailed information regarding the examinations and the awarding of this scholarship will be furnished by the Secretary of Sibley College or by the Registrar of Cornell University.

**Sibley Prizes in Mechanic Arts.** Under the gift of the late Hiram Sibley, made in 1884, the sum of one hundred dollars will be annually awarded in five prizes to juniors and seniors in Sibley College who have received the highest marks in scholarship in at least three full terms of work required in the Sibley College course and done in that college. The prizes are $30, $25, $20, $15 and $10.

**The Fuertes Memorial Prizes in Public Speaking,** founded by Charles H. Baker, C.E. '86, consisting of $100 and $20 respectively, are awarded annually to those members of the junior and senior classes in the Colleges of Engineering and Architecture, who may be selected after competitive trial in public speaking. The orations delivered in competition for these prizes are to be original compositions on technical subjects and must be argumentative in character. In making the awards both the character of the argument and the manner of delivery will be considered.

***The Wurts Loan Fund,** the gift of Alexander Jay Wurts, in memory of his mother Laura Jay Wurts, was founded in 1912 to assist needy students of the two upper classes in Sibley College. Upon the recommendation of the Dean of Sibley College, loans from the income from this fund may be awarded by the Faculty of Sibley College, with the approval of the Treasurer, to one or more students each year.

## PREPARATION FOR ADMISSION

As the instruction in Sibley College is almost entirely of a scientific or engineering character, and as, at best, the student has only very limited opportunities for instruction along broader lines, it is desirable that the training for entrance

*For information regarding the other loan funds and the opportunities for self support see the General Circular of Information or the pamphlet on Financial Assistance and Self-Help.

should be as liberal as possible with stress on subjects like language and history, and with physics and chemistry deferred until after entering the University.

While three years of any one of the foreign languages listed on page 15 will be accepted by this college as satisfying the language requirement for admission, prospective students are strongly advised to study German and French, not only for their cultural value but for their engineering literature. It is of advantage for those entering the engineering courses to have had some instruction in free-hand sketching.

Students who have had some engineering experience usually gain more than others from the courses of Sibley College; hence it is recommended that prospective students spend at least one summer vacation in touch with some kind of engineering work.

As already mentioned, it is desirable for the student to obtain, if possible, the training of a liberal college course before entering Sibley College, and those who have not had this broader education are recommended to take either the five year course or the six year course, if they can afford the additional time and expense involved.

## ADMISSION AND CLASSIFICATION

The following five classes of students are admitted to the work of the Sibley College of Mechanical Engineering and the Mechanic Arts:

1. Persons who desire to begin as freshmen the regular four year undergraduate courses relating to mechanical, electrical, industrial or mining engineering and leading to the degree of Mechanical Engineer. (See page 16 for requirements for admission, pages 24 to 28 for course relating to mechanical, electrical and industrial engineering, and pages 29 and 30 for course relating to mining engineering.)

2. Persons who desire to begin as freshmen in the five year course leading to the degree of Mechanical Engineer. (See pages 16, 31 and 32).

3. Persons who have already attended some technical or similar institution and desire to enter with advanced standing the regular course in Sibley College leading to the degree of Mechanical Engineer. (See page 17).

4. Persons who desire to enter as special students not candidates for the degree of Mechanical Engineer. (See page 18).

5. Graduate Students. (Registration in Graduate School of Cornell University. See Announcement of the Graduate School.)

For the combined courses of six years leading to the degrees of Bachelor of Arts and Mechanical Engineer, see page 32.

## List of Subjects for Entrance to Sibley College

NOTE:—The term unit means the equivalent of five prepared recitations a week for one year in a subject. See General Circular of Information for detailed information.

### Group *a*

| Subject | Units |
|---|---|
| English A | 2 |
| English B | 1 |
| Algebra, Elementary | 1 |
| Algebra, Intermediate | ½ |
| Algebra, Advanced | ½ |
| Geometry, Plane | 1 |
| Geometry, Solid | ½ |
| Plane Trigonometry | ½ |

NOTE

**Four year Course:** All seven units in Group *a* are required.

**Five year Course:** From Group *a* five units are required, including

| | |
|---|---|
| English A & B | 3 units |
| El. Algebra | 1 " |
| Plane Geometry | 1 " |

### Group *b*

| Subject | Units |
|---|---|
| History—Ancient | ½ or 1 |
| " Modern | ½ or 1 |
| " American, Civics | ½ or 1 |
| " English | ½ or 1 |
| German—First Year | 1 |
| " Second Year | 1 |
| " Third Year | 1 |
| French— First Year | 1 |
| " Second Year | 1 |
| " Third Year | 1 |
| Greek— First Year | 1 |
| " Second Year | 1 |
| " Third Year | 1 |
| Latin— First Year | 1 |
| " Second Year | 1 |
| " Third Year | 1 |
| " Fourth Year | 1 |
| Spanish—First Year | 1 |
| " Second Year | 1 |
| " Third Year | 1 |
| Italian— First Year | 1 |
| " Second Year | 1 |
| " Third Year | 1 |
| Spherical Trigonometry | ½ |
| Physics | 1 |
| Chemistry | 1 |
| Physical Geography | ½–1 |
| Biology* | 1 |
| Botany* | ½–1 |
| Zoology* | ½–1 |
| Agriculture | ½–1 |
| Drawing | ½–1 |
| Manual Training | 1 |
| Any other High School Subject | ½–1 |

NOTE

**Four year Course:** From Group *b* eight units are required, including

| | |
|---|---|
| Foreign Language (one) | 3 units |
| History | 1 " |
| Elective | 4 " |

**Five year Course:** From Group *b* ten units are required, including

| | |
|---|---|
| Foreign Language (one) | 3 units |
| History | 1 " |
| Elective | 6 " |

Among the electives may be included Intermediate Algebra, Advanced Algebra, Solid Geometry or Plane Trigonometry of Group *a*.

*If an applicant has counted Biology (1) he may not also offer Botany (½) or Zoology (½).

Credit for entrance subjects* may be secured in the following ways:

1. By passing the required Cornell University Entrance Examinations held in September in Ithaca and New York City, and in January in Ithaca.

2. By passing the College Entrance Examination Board Examinations held in June in various places. (Address the Secretary of the College Entrance Examination Board, P. O. Sub-station 84, New York City.)

3. By passing the Regents' Examinations (for students who have prepared in New York State).

4. By presenting an acceptable school certificate.

For the regulations relating to admission at the beginning of the second term see next page.

## 1. REQUIREMENTS FOR ADMISSION TO THE FRESHMAN CLASS IN THE FOUR YEAR COURSE

[All correspondence concerning admission to the freshman class should be addressed to the Registrar of Cornell University. All credentials relating to the admission of new students must be in the hands of the Registrar before September first.]

For admission to the four year course the applicant must be at least sixteen years of age and must satisfy either A or B of the following scholastic requirements:

(A) He must offer 15 units from the List of Entrance Subjects given on page 15, and besides including all of Group *a* (three units of English and four of Mathematics), he must offer from Group *b*, one unit of History, three units of *one* Foreign Language (ancient or modern, but preferably German or French) and four other units, preference being given to subjects other than Physics and Chemistry, as these are included in the engineering course; or

(B) He may offer, as a substitute for A, either the Arts College Entrance Diploma, or the Science College Entrance Diploma, issued by the Department of Education of the State of New York, provided he receives credit for the four units of Mathematics of Group *a*.

## 2. REQUIREMENTS FOR ADMISSION TO THE FRESHMAN CLASS IN THE FIVE YEAR COURSE

[All correspondence concerning admission to the freshman class should be addressed to the Registrar of Cornell University. All credentials relating to the admission of new students must be in the hands of the Registrar before September first.]

For admission to the five year course the applicant must be at least sixteen years of age and must meet the following entrance requirements:

(A) He must offer fifteen units from the List of Entrance Subjects given on page 15 and must include English 3 units, Elementary Algebra 1 unit and Plane Geometry 1 unit (from Group *a*), 3 units in one Foreign Language and 1 unit of History (from Group *b*) and six other units from either group; or

(B) He may offer, as a substitute for A, either the Arts College Entrance Diploma, or the Science College Entrance Diploma, issued by the Education Department of the State of New York.

*For details concerning entrance subjects and methods of admission see the General Circular of Information.

### 3. ADMISSION FROM OTHER COLLEGES

[All correspondence concerning admission from other colleges should be addressed to the Registrar of Cornell University.]

A student who, having already attended some technical or similar institution of collegiate rank, desires to enter the regular course in the Sibley College of Cornell University should file with the Registrar of Cornell University, on an official blank to be obtained from him, a formal application for admission to Sibley College along with an official certificate from the institution already attended, of his honorable dismissal, his entrance examinations in detail, his terms of attendance and the amount of work that he has completed, and a detailed statement of the courses pursued. He should also send a catalogue of the institution, writing on it his name and marking the entrance requirements that he has satisfied and each subject that he has completed.

### 4. ADMISSION AT THE BEGINNING OF THE SECOND TERM

Certificates and credentials for admission at mid-year must be in the hands of the Registrar not later than January 15th.

Students who meet in full the requirements for admission as freshmen in either the four year or the five year course may enter Sibley College at mid-year to pursue courses which will be specially outlined to suit each individual case and which will lead to the degree of Mechanical Engineer at the end of four and a half years.*

In order to secure admission at mid-year with advanced standing in the regular four year course in Sibley College, with a view to graduating in less than four years, the applicant must have attended an institution of collegiate rank, and must secure credit for such university courses as will enable him, by attending during the remainder of the college year and (possibly) during the succeeding Summer Session, to substantially complete the year's work scheduled for the class he wishes to enter.

On application made to the Registrar on or before January 15th in any year, special entrance examinations in any of the University entrance subjects may be arranged for students who must be examined in one or more subjects to complete their requirements for admission at the middle of the year. These special entrance examinations will be held in Ithaca on or about January 25th of each year.

### 5. ADMISSION AS SPECIAL STUDENTS

[All correspondence concerning the admission of special students should be addressed to the Secretary of Sibley College. All applications for admission must be made on the official blanks provided for the purpose and obtainable from the Secretary.]

Men at least twenty-one years of age may be admitted as special students in mechanical engineering not candidates for a degree, provided they have had sufficient experience in some line of mechanical engineering to show that they

*Those meeting the requirements of admission to the five year course must complete all the Mathematics of Group *a* (page 15) before the following fall. But one unit of this Mathematics can be taken during the first term of attendance; further shortage may be removed by attending the following Summer Session or by taking the entrance examinations in the fall.

are worthy of special consideration because of demonstrated aptitude in engineering branches, and provided they give evidence of ability to do creditable work in the College, and provided they have neither been previously admitted to the University as regular students nor have been refused admission.

They are required to have completed before admission the mathematical preparation of the regular students,—of either the four year or the five year courses (page 15)—and may be held for examination in these subjects. There are no special courses for special students; such students must conform to either the four year course as outlined on pages 24 to 28, or to the five year course (pages 31 and 32), depending on their preparation. Upon fulfilment of all entrance requirements special students may become regular students and candidates for the degree of M.E. Special students will not, however, be permitted to make up deficiencies in entrance subjects by attending University instruction in those subjects.

## 6. ADMISSION AS GRADUATE STUDENTS

[All correspondence relating to graduate work, graduate scholarships and fellowships should be addressed to the Dean of the Graduate School.]

In all departments in Sibley College, work is arranged to meet the special needs of graduate students and, in addition, the head of the Department of Engineering Research will co-operate in every way to assist the graduate students in mechanical and electrical engineering, and will aid in providing apparatus and other facilities for graduate work. Graduate students register in the Graduate School and not in Sibley College. To be registered as a candidate for the degree of Master of Mechanical Engineering, the student must have satisfied the equivalent of the entrance requirements and of the University subjects specified by Sibley College for the M.E. degree. For further information regarding admission, registration, etc., see Announcement of the Graduate School.

## 7. PAYMENTS TO THE UNIVERSITY*

[For detailed information regarding payments to the University and the expense of living in Ithaca, see the General Circular of Information.]

Briefly, students entering Sibley College are subject to a matriculation fee of $5 and to the following payments:

| | 1st Term | 2d Term |
|---|---|---|
| University Tuition ($150 yearly) | $85 | $65 |
| Sibley Fee ($25 yearly)† | 12.50 | 12.50 |
| Infirmary Fee ($6 yearly) | 3 | 3 |

Each student in the Department of Physical Culture is required to pay a fee of $2 per term and those taking laboratory courses in other colleges of the University must pay to the Treasurer a fee or deposit for materials used in the work. Payments must be made within 20 days after registration. A graduation fee of $10 must be paid ten days before commencement. The amount will be refunded should the degree not be conferred. Tuition is free to students holding State Scholarships.

---

*All tuition and other fees may be changed or increased by the Trustees to take effect at any time without previous notice.

†Students in the five year and four and one-half year courses need pay this fee for but eight terms.

Non-engineering students taking shopwork or laboratory work in Sibley College must pay for such instruction a fee of $3.50 per record hour. When a student has taken, while in a non-engineering college of the University, part of the work required for the M.E. degree, such student before receiving that degree shall be required to have paid to the University Treasurer such amount as would have been paid if all such work had been taken while registered in Sibley College. The University Treasurer is empowered to adjust the arrears to be paid in irregular cases arising under the foregoing requirements.

## GENERAL OUTLINE OF INSTRUCTION

The instruction in mathematics, chemistry, physics, geology, and general economics is given in the College of Arts and Sciences. All other regular subjects in the course are of an engineering nature and are given in Sibley College in the following departments: 1. Machine Construction; 2. Machine Design; 3. Mechanics of Engineering; 4. Power Engineering; 5. Experimental Engineering; 6. Electrical Engineering; 7. Industrial Engineering; 8. Engineering Research.

The following is a brief outline of the scope and purposes of instruction in the various departments of Sibley College.

### 1. DEPARTMENT OF MACHINE CONSTRUCTION

The object of the instruction in this Department is not only to familiarize the student with modern shop operations and processes, and with the workability of materials used in engineering construction, but more particularly to give him instruction in the principles of manufacturing and duplication of parts, and in the selection and arrangement of shop equipment.

In the freshman year the student attends lectures on the general principles of engineering; he receives instruction in the foundry in moulding, core making, mixing of metals, operation of cupola, the use of moulding machines, etc., with consideration given to the methods and appliances for sweepwork, large work, and production in quantities; and he is given manual instruction in the forging and heat treatment of both iron and steel, supplemented with illustrations of drop-hammer work and methods used in manufacturing in large quantities.

In the sophomore year wood working is taught with the object not only of familiarizing the student with wood-working tools and machines and their use, but more especially to teach him pattern and core-box making. Instruction is also given in large pattern work and sweepwork.

In the junior year the principles of manufacturing are taught, supplemented by work of an illustrative character in the machine shop, where carefully graded instruction is given in the use of measuring instruments, hand tools, and machine tools, including semi-automatic and automatic tools, and in the use of jigs and special fixtures for manufacturing in large quantities. The administration of this shop in particular is intended to illustrate as far as possible approved methods of shop management and operation, and to give the student a general idea of time keeping, piece work, premium plan, and other wage systems. The instruction is given to a great extent in connection with the construction of commercial machines.

## 2. DEPARTMENT OF MACHINE DESIGN

The courses in drawing, design and shopwork, are so organized as to secure the close correlation of these subjects. Many of the exercises in the drawing room, pattern shop, foundry, and machine shop involve work on the same machine parts. In this way the student has presented to him all the necessary steps from the inception to the production of finished machine parts.

Instruction in this Department begins with lettering, the use of drawing instruments, the elements of mechanical drawing according to the best practice in commercial drafting rooms, and empirical design.

Following this the student is taught descriptive geometry and the principles of mechanism. The drawing-room work in the latter course is closely related to the class-room instruction in cams, gearing, and linkages, with application to the kinematic design of machines.

After the student has received instruction in mechanism and applied mechanics, he takes up the mathematical side of machine design, the instruction being given by lectures, recitations, and drawing-room work. The student "lays out" mechanisms on the drawing board, analyzes the force, velocity, and energy transformations involved; proportions the members with consideration of strength, rigidity, and shop operations; and makes working drawings for the complete designs of machines.

The Department offers two of the optional groups that are open to seniors. The first includes instruction in the design of industrial structures and in the selection and arrangement of equipment for factories, power plants, etc. The second senior option offers instruction in ship design and construction, and includes both lectures and drafting-room work bearing on the theoretical and practical design of ships and also a discussion of the important features in the resistance, propulsion and powering of vessels.

## 3. DEPARTMENT OF MECHANICS OF ENGINEERING

Instruction is given in this department in theoretical and applied mechanics beginning with a course for sophomores in the fundamental principles of statics and kinetics, with application to mechanisms, followed by a comprehensive study of the mechanics of materials with their application to engineering design. An effort is made to teach students to think rather than to memorize. With this in view, the free-body method is used in the solution of problems involving forces, and students are required to work from fundamental definitions and principles rather than from formulas.

For juniors a course in hydraulics is given. A broad knowledge of the fundamental principles is deemed of more value than familiarity with special formulas or numerical coefficients. For seniors an elective course on hydraulic turbines is offered. While the theory of turbines is outlined, stress is laid upon the practical side of the subject, the object being to make the course of definite value for those expecting to take up hydro-electric work. The laboratory instruction in hydraulics is given in the Department of Experimental Engineering.

## 4. DEPARTMENT OF HEAT-POWER ENGINEERING

All students in Sibley College receive instruction in this department in their junior and senior years with the object of training them in the methods of solution

of problems involved in the theory, design, and economics of heat engines and their auxiliary apparatus, considered both separately and in combination in power plants.

The work of this department begins with lectures and recitations on the elements of heat-power engineering, including the study of the elementary thermodynamics of gas and vapors, theoretical and actual cycles, and steam engines. This is followed by a study of steam turbines, internal combustion engines, fuels and combustion, furnaces, boilers, draft apparatus, producers, heat transmission, condensers, feed water-heaters and other power-plant auxiliaries, the flow of gases and vapors, refrigeration, and air compressors.

In addition to taking these required courses, the student in his senior year may specialize in the design of steam engines or of internal combustion engines, by taking the lecture and drafting courses specially devoted to these subjects. He may also attend special lecture courses on steam turbines, steam boilers, and gas manufacture.

## 5. DEPARTMENT OF EXPERIMENTAL ENGINEERING

Instruction in this department begins in the sophomore year with the study of materials of engineering, their manufacture, properties, and uses.

Throughout the junior and senior years the student receives instruction in the very completely equipped mechanical laboratories (described on page 9) not only to familiarize him with the various types of testing apparatus and to give him skill in their use, but to teach him the best methods of research. Briefly, the courses include the use of computing machines; the testing of engineering materials, with determination of influences of composition and heat treatment; the calibration and use of indicators, gauges, thermometers, dynamometers, etc.; tests of lubricants; fuel calorimetry; steam calorimetry; valve setting; tests of boilers, steam engines, turbines, pumps, heaters, condensers, injectors, and other steam apparatus; tests of air compressors and refrigerating machines; tests of external and internal combustion gas and oil engines; and tests of hydraulic machinery.

## 6. DEPARTMENT OF ELECTRICAL ENGINEERING

Instruction in electrical engineering begins in the junior year and is based on the required courses in physics and mechanics. The instruction begins with the elements of electrical engineering taught by lectures and recitations, both experimental and theoretical, by problems solved in the computing room and by laboratory exercises. Briefly, this introductory course covers a review of the fundamental laws of electric and magnetic circuits, electrical measurements, and the theory, structural features, and operating characteristics of electrical apparatus. Direct current work is covered during the first term and alternating currents during the remainder of the year.

In the senior year the students who are specializing in mechanical engineering have a brief advanced laboratory course and receive instruction in the solution of such electrical problems as are encountered in general engineering practice.

Those who specialize in electrical engineering receive in the senior year advanced instruction by lectures, recitations, computation exercises, and labora-

tory experiments. This subject is approached from three points of view: (a) analytical; (b) graphical; and (c) experimental. Each senior follows through a series of problems in which, starting with the data given, he makes application of the fundamental principles involved and predicts the performance of the mechanism or apparatus under various conditions of operation, or he determines the necessary dimensions for specified performance. In the laboratory, experiments in great variety show the characteristics of machines under operating conditions, and familiarize the students with the construction and operation of the various commercial types of electrical apparatus.

During the second term of the senior year a number of courses are offered by specialists in the different departments of the field of electrical engineering, these courses being planned simply to illustrate the manner in which the several industrial requirements are met. Electric railway engineering, power generation and transmission, the design of electrical machinery, wireless telegraphy and electric waves are among the topics treated this year. The students do not become engineers or designers in these various fields, but they learn enough of each to appreciate the kind of problems which predominate. Recitations in this work are carried on in small sections, thus securing to the student a large amount of individual attention which is devoted primarily to developing originality and initiative.

A considerable amount of undergraduate research is being carried on from year to year by juniors and seniors, under the supervision of the electrical department. The purpose of this research is to develop initiative and resourcefulness, to promote interest in inventions, and to prepare the student for commercial research or for more advanced academic work.

## 7. DEPARTMENT OF INDUSTRIAL ENGINEERING

Until recently the field of the mechanical engineer was a comparatively narrow one and comprised mainly the design, construction and operation of machinery. As industry has developed, however, many technically trained men have entered the fields of manufacturing, selling and administration. This is a natural and increasing tendency since industrial development rests mainly upon a scientific basis. There are few lines of human activity today that are not connected in some way with applied science and this is particularly true of those lines known by the general term of engineering.

The success of the engineer in times past in meeting these commercial requirements, for which he had received no special training, was probably due to the method of attack characteristic of the engineer and to superior knowledge of the technical side of the work. But the commercial demands upon the engineer are now becoming so great that special training is necessary to equip him more completely for this larger field. This will appear more evident when it is considered that a large number of the graduates of mechanical engineering colleges go into the commercial side of engineering.

Therefore, in addition to training in the fundamental principles of engineering, every student in the regular courses in Sibley College is given some work in industrial organization and administration before he graduates; while in this department a more complete provision is made in the senior year for those who wish to specialize in the commercial side of engineering.

The work of the department begins in the junior year in which all students in the college are given a course of instruction in the basic principles of industrial organization. An optional group of studies is offered in the senior year for those who wish to specialize somewhat in this line of work, this option consisting of the engineering subjects required in all senior options, special courses of lectures and drawing room work in plant organization and arrangement, and a carefully selected group of economic studies treating of accounting, business law, industrial history and kindred subjects.

### 8. DEPARTMENT OF ENGINEERING RESEARCH

Engineering research by undergraduate students is carried on in this department under the supervision of a separate corps of specialists who devote their entire time to this work. Those who have shown proficiency in experimental engineering may have opportunity to conduct original investigations under expert guidance, and, as occasion offers, may assist in commercial tests, made at the University or elsewhere, of materials, prime movers, power plants, etc. The equipment of every department is available for this work and the specialists in any department may be consulted.

In case the investigation or research is sufficiently extended, the student is encouraged to embody the work in a thesis. Research, or Thesis, may be elected during the senior year by a limited number who have shown suitable adaptability for investigation. Arrangements for this work should be made with the Department of Engineering Research during the junior year if possible.

Besides the courses in engineering research and power-plant testing, lecture courses, primarily for seniors and graduate students, are given on motor car construction and on heating and ventilating.

This department will co-operate in every way to assist graduate students in mechanical, electrical, industrial and mining engineering and will aid in providing apparatus and other facilities for graduate work.

**Non-Resident Lecturers.** Supplementing the regular course of instruction, lectures are delivered from time to time by non-resident specialists in the profession.

## COURSES OF STUDY

The following courses of study are offered:

1. The regular course leading to the degree of Mechanical Engineer and covering a period of four years (see pages 24 and 25 for the first three years of the course). In the senior year of this course the student may specialize in:

Electrical Engineering (page 25)
Heat-Power Engineering,—Steam, Gas, etc. (page 26)
Structural and Plant Engineering (page 26)
Ship Design and Construction (page 27)
Industrial Engineering (page 27).

2. The special four year course in subjects relating to Mining Engineering see page 29).

3. A five year course leading to the degree of Mechanical Engineer (see pages 31 and 32).

4. A six year course, in which the student is registered in the College of Arts and Sciences during his first three years of residence. The six year course leads to the degree of Bachelor of Arts at the end of the fourth year and to the degree of Mechanical Engineer at the end of the sixth year (see page 32).

## COURSES LEADING TO THE DEGREE OF MECHANICAL ENGINEER

### 1. THE REGULAR FOUR YEAR COURSE

In the regular four year course leading to the degree of Mechanical Engineer instruction is the same for all students during the first three years. In the fourth year, some opportunity is offered for specializing in the different branches of mechanical, electrical and industrial engineering. The sequence of subjects and the time devoted to each course are given in the following tables. Detailed descriptions of the courses are given on pages 33 to 46, and the requirements for admission are stated on page 16.

NOTE. In referring to courses the following abbreviations are used: Shop, S; Machine Design, D; Mechanics of Engineering, M; Power Engineering, P; Experimental Engineering, X; Electrical Engineering, E; Industrial Engineering, I; Engineering Research, R. For description of courses given by other colleges, see pages 33 and 34.

About three hours of actual work in shops, laboratories, computing work, or drawing count as one hour credit in the schedule.

#### Freshman Year

| Course | Page | No. Course | Hours 1st Term | Hours 2d Term |
|---|---|---|---|---|
| Analytic Geometry and Calculus | 33 | 6 | 6 | 6 |
| Chemistry | 33 | 1 | 0 | 6 |
| Physics | 33 | 3 | 6 | 0 |
| Drawing and Desc. Geom. | 35 | D 1, 2 | 3 | 3 |
| Foundry | 35 | S3 | 2 or 0 | 0 or 2 |
| Forge | 35 | S4 | 0 or 1 | 1 or 0 |
| Engineering Principles | 35 | S2 | 0 or 1 | 1 or 0 |
| Military Drill | 34 | 1 | 1 | 1 |

#### Sophomore Year

| Course | Page | No. Course | Hours 1st Term | Hours 2d Term |
|---|---|---|---|---|
| Mechanics of Engineering | 38 | M5, 6 | 5 | 5 |
| Physics, Recitations | 33 | 8, 9 | 2 | 2 |
| Physics, Laboratory | 33 | 14 | 2 | 2 |
| Chemistry | 34 | 6 | 0 or 5 | 5 or 0 |
| Kinematics | 36 | D6 | 0 | 2 |
| Drawing | 35, 36 | D 5, 7 | 3 | 3 |
| Materials | 40 | X6 | 2 | 0 |
| Pattern Making | 35 | S7 | 3 or 0 | 0 or 3 |

In addition to the above, three hours a week of either Military Drill or Physical Culture must be taken in the sophomore year.

### Junior Year

| Course | Page | No. Course | Hours 1st Term | Hours 2d Term |
|---|---|---|---|---|
| Heat-Power Engineering | 39 | P10 | 3 | 3 |
| Electrical Engineering | 42 | E14 | 2 | 2 |
| Electrical Engineering | 42 | E15 | 2 | 2 |
| Mechanical Laboratory | 40 | X10, 11 | 3 | 3 |
| Machine Design— | | | | |
| (a) Drawing | 36 | D10 | 2 | 2 |
| (b) Lectures and Recitations | 36 | D16 | 3 | 3 |
| Machine Work | 35 | S10 | 2 | 2 |
| Industrial Organization | 44 | I 11 | 2 | 0 |
| Hydraulics | 38 | M12 | 0 | 2 |

### Senior Year

In the senior year the regular student must complete one of the options (A to E inclusive) which are given on the following pages. All these options have, in common, courses in Power Plant Design, Mechanical Laboratory, Electrical Engineering, and Economics; and under each option are lecture and drafting courses devoted to the special branch of engineering to which the option relates. In addition, provision is made in most of the options for electing, to a limited extent, courses given in any college of the University.

### Option A. Electrical Engineering

The senior option in Electrical Engineering is planned to give to students fundamental preparation for positions in electric design, manufacture and operation, and for consulting work.

The student who selects this option is required to take, in addition to Power Plant Design, Mechanical Laboratory and Economics, special subjects as follows: electrical laboratory (E. 28), in which he actually investigates the operation of electrical machinery, and the theoretical courses (E. 20 and 21), in which he is taught the laws of electricity and magnetism in their practical form and is shown how to apply them to the design of electrical apparatus and how to predict the results in operation.

In addition to these general fundamental electrical courses the student may select one or more special subjects, such as electric power generation or transmission, railway work, wireless telegraphy, illumination, etc., or an electrical thesis.

Senior Electrical Engineering Option:—

| Course | Page | No. Course | Hours 1st Term | Hours 2d Term |
|---|---|---|---|---|
| Power Plant Design | 39 | P20 | 3 | 3 |
| Mechanical Laboratory | 41 | X20 | 3 | 0 |
| Electrical Laboratory | 43 | E28 | 4 | 4 |
| Electrical Machinery | 42 | E20 | 2 | 2 |
| Electrical Machinery | 42 | E21 | 4 | 4 |
| Economics | 34 | 52 | 2 | 2 |
| *Elective (limited) } or Thesis, | | | 0 or 2 | 2 or 0 |
| Elective (open) { R. 27, page 45 | | | 0 | 2 |

*Limited to E22, 23, 25, 27, 30, 34, Phys. 15, 27, 33 and 34 and M21.

### Option B. Heat-Power Engineering

The object of this option is to train men in the design of steam and internal combustion engines and auxiliary apparatus, and also in the design and arrangement of heat-power stations.

The special work of this option includes lectures and class room discussion of the theoretical and practical considerations entering into the design of valve gears and engine details; governor design; balancing; determination of fly-wheel weights; selection and arrangement of machinery for steam and internal combustion power plants. A drafting room course is given for the practical solution of problems to illustrate the theoretical discussions. In addition, among the elective courses, the student may include the courses in Boiler Design, Steam Turbines and Gas Manufacture and Transmission.

Senior Heat-Power Engineering Option:—

| Course | Page | No. Course | Hours 1st Term | Hours 2d Term |
|---|---|---|---|---|
| Power Plant Design | 39 | P20 | 3 | 3 |
| Mechanical Laboratory | 41 | X20, 21 | 3 | 3 |
| Electrical Engineering | 44 | E35 | 2 | 2 |
| Economics | 34 | 52 | 2 | 2 |
| Heat-Power Machinery Design | 39 | P23 | 3 | 3 |
| Drawing and Design | 40 | P24 | 2 | 2 |
| Elective (or Thesis, R. 27, page 45) | | | 4 | 4 |

### Option C. Structural and Plant Engineering

This option is intended for those who wish instruction in the general engineering problems involved in plant construction and equipment. It is intended to develop skill in the technical side of the planning of industrial plants rather than in detail design of machinery, and also to give the student a drill in the methods of attacking problems in plant design. The first part of the courses that are a special feature of this option treats of the graphics of construction as applied to standard trusses and similar structures. This is followed by instruction in the theory and practice of footings, foundations, sidewalls and such other details as confront the engineer in planning industrial works. The second part of these courses is devoted to the selection and arrangement of machinery, using the knowledge of the characteristics of machines that the student has acquired in other courses to guide him in selecting the proper units. Each student is required to make a layout of some industrial plant, such as a power house, making the skeleton outline of the buildings, selecting and locating the machinery and carrying the design to the point usually required in a good preliminary design.

Among the optional hours the student may, if he desires, include the elective courses in Steam Boilers, Steam Turbines, Gas Power Machinery and Engineering Notes.

Senior Structural and Plant Engineering Option:—

| Course | Page | No. Course | Hours 1st Term | Hours 2d Term |
|---|---|---|---|---|
| Power Plant Design | 39 | P20 | 3 | 3 |
| Mechanical Laboratory | 41 | X20, 21 | 3 | 3 |
| Electrical Engineering | 44 | E35 | 2 | 2 |
| Economics | 34 | 52 | 2 | 2 |
| S. & P. Engineering Design | 36 | D22 | 2 | 2 |
| Drawing and Design | 37 | D23 | 3 | 3 |
| Elective (or Thesis, R 27, p. 45) | | | 4 | 4 |

### Option D. Ship Design and Construction

The primary purpose of Option D is to train men who intend to enter ship yards to make a life work of ship design and construction, but it may be taken profitably by men intending to follow other lines of mechanical engineering.

In this option the fundamental principles underlying the design of all the types of mercantile, war and pleasure vessels are discussed in detail. This is productive of problems in hydro-statics, hydro-dynamics and aero-dynamics, the solutions of which are deeply interesting, not only to the Naval Architect but to the Mechanical Engineer.

The materials used in the construction of vessels, their equipment, and their machinery, are taken up and their economic and structural values determined.

The speed and powering of vessels are fully dealt with along the lines indicated by the results derived from the latest experimental research, as well as those obtained from experience with actual vessels.

The different types of propelling machinery are critically examined from the standpoint of their adaptability in the three classes of vessels referred to above.

Specifications, contracts and the organization of shipyards, docks and engineering shops, form the subjects of interesting and useful discussions.

Senior Ship Design and Construction Option:—

| Course | Page | No. Course | Hours 1st Term | Hours 2d Term |
|---|---|---|---|---|
| Power Plant Design | 39 | P 20 | 3 | 3 |
| Mechanical Laboratory | 41 | X 20, 21 | 3 | 3 |
| Electrical Engineering | 44 | E 35 | 2 | 2 |
| Economics | 34 | 52 | 2 | 2 |
| Ship Design | 37 | D 25 | 3 | 3 |
| Speed and Power of Ships | 37 | D 26 | 0 | 2 |
| Drawing and Computations | 37 | D 27 | 3 | 3 |
| Specifications, Contracts, etc. | 38 | D 28 | 2 | 0 |
| Elective | | | 0 | 2 |

### Option E. Industrial Engineering

This option is intended for those who wish to enter the commercial side of engineering or who are particularly interested in industrial organization and administration. In the special courses relating to this option are discussed the modern time-keeping and cost-finding systems, methods of planning work and insuring production, time and motion studies, purchasing, problems in adminis-

tration, plant locating, heating, lighting, powering, safety engineering, fire protection and similar subjects. In the drafting and designing course the graphical work includes the application of these fundamental principles to planning industrial enterprises. The time alloted to economics will be devoted to such courses as accounting, business law, government control of industry and financial history. Students who wish to elect this option must receive credit for History and Political Science 52, or its equivalent, before the senior year, since this is a prerequisite for some of the courses required in the option. Students expecting to elect this option are also advised to read for preparation as much industrial history and kindred subjects as possible.

Senior Industrial Engineering Option:

| Course | Page | No. Course | Hours 1st Term | Hours 2d Term |
|---|---|---|---|---|
| Power Plant Design | 39 | P 20 | 3 | 3 |
| Mechanical Laboratory | 41 | X 20, 21 | 3 | 3 |
| Electrical Engineering | 44 | E 35 | 2 | 2 |
| Industrial Administration | 44 | I 20 | 2 | 2 |
| Drawing and Design | 45 | I 22 | 3 | 3 |
| Safety Eng'g and Fire Protection | 45 | I 23 | 0 | 2 |
| Economics, as prescribed | | | 6 | 4 |

**Suggested Technical Electives.** These electives may be taken only with the approval of the Class Adviser and of the departments concerned. For detailed information see announcements of the departments giving the courses.

FOR SENIORS ONLY

| Course | Page | No. Course | Hours 1st Term | Hours 2d Term |
|---|---|---|---|---|
| Thesis | 45 | R27 | 0–8 | 8–0 |
| Steam Boiler Design | 40 | P30 | 2 | 0 |
| Steam Turbines | 40 | P25 | 0 | 2 |
| Gas Manuf. and Distribution | 40 | P28 | 2 | 0 |
| Gas Power Machinery | 40 | P29 | 0 | 2 |
| Advanced Heat-Power Engineering | 40 | P40 | 1–3 | 1–3 |
| Engineering Research | 45 | R22 | 1–3 | 1–3 |
| Power Plant Testing | 45 | R23 | 1–3 | 1–3 |
| Motor Car Construction | 45 | R24 | 0 | 1 |
| Heating and Ventilating | 45 | R25 | 0 | 2 |
| Engineering Notes | 37 | D24 | 0 | 2 |
| Speed and Power of Ships | 37 | D26 | 0 | 2 |
| Advanced Designing | 38 | D40 | 1–3 | 1–3 |
| Industrial Administration | 44 | I20 | 2 | 2 |
| Safety Eng'g and Fire Protection | 45 | I23 | 0 | 2 |
| Advanced Industrial Engineering | 45 | I40 | 1–3 | 1–3 |
| Special Elect. Eng. Problems | 44 | E33 | 1–3 | 1–3 |
| Engineering Mathematics | 43 | E30 | 2 | 2 |
| Hydraulic Turbines | 38 | M21 | 2 | 0 |
| Railway Cons. and Maintenance | | C.E.63 | 0 | 2 |
| Concrete Construction | | C.E.77 | 0–3 | 3–0 |
| Alternating Currents | | Phys.33 | 2 | 0 |
| Electrical Lab. Practice | | Phys.34 | 3 or 0 | 0 or 3 |

### General Electives

Students having the necessary preparation and having the approval of their Class Adviser may take subjects in the following list in any year, except when the year is indicated by a figure immediately following the subject. The choice of studies is not limited to this technical list; the student may, with the approval of his Class Adviser and of the department concerned, take any subject in any department in the University.

| Course | No. Course | Hours 1st Term | Hours 2d Term |
|---|---|---|---|
| Surveying | C.E.12 | 0 | 2 |
| Spec. and Contracts (3 or 4) | C.E.90 | 2 or 0 | 0 or 2 |
| Elem. of Elect. Ry. Pract. (3 or 4) | E25 | 0 | 2 |
| Design of Elect. Machinery (4 E.E.) | E22 | 0 | 2 |
| Generation of Elect. Energy (4 E.E.) | E23a | 2 | 0 |
| Transmission of Elect. Energy (4 E.E.) | E23b | 0 | 2 |
| Assaying | Chem. 18 | 3 | 0 |
| Adv. Quant. Anal. | Chem. 14 | 1–3 | 1–3 |
| Adv. Quant. Anal. Lectures | Chem. 15 | 2 | 0 |
| Qual. and Quant. Gas Anal | Chem. 19 | 0–2 | 2–0 |
| Tech. Gas Anal | Chem. 20 | 0–2 | 2–0 |
| Chemistry of Gases (4) | Chem. 49 | 0 | 1 |
| Photometry | Phys. 15 | 1–3 | 1–3 |
| Photometry and Illumination | Phys. 27 | 2–6 | 2–6 |
| Photometry and Illumination | Phys. 43 | 2 | 0 |
| Photography | Phys. 18 | 2 or 0 | 0 or 2 |
| Bldg. Stone and Clay Prod. | Geol. 30 | 2 | 0 |
| Engineering Geology | Geol. 31 | 3 | 3 |
| General Econ. Geol | Geol. 32 | 2 or 3 | 2 or 3 |
| Mining of Mineral Deposits | Geol. 34 | 2 | 2 |

Economics: Accounting, Business Law, Corporations and Trusts, Money and Banking, Labor Problems, Railway Transportation, Public Utilities, Government Control of Industries, etc.

## 2. A FOUR YEAR COURSE IN SUBJECTS RELATED TO MINING ENGINEERING

Students who have satisfied the requirements for admission as freshmen in the four year course may substitute in place of the regular course given on pages 24 to 28, the following special four year schedule of subjects relating to Mining Engineering and leading to the degree of Mechanical Engineer.

Note. In referring to courses, the following abbreviations are used: Shop, S; Machine Design, D; Mechanics of Engineering, M; Power Engineering, P; Experimental Engineering, X; Electrical Engineering, E; Engineering Research, R. About three hours of actual work in shops, laboratories, computing work, or drawing count as one hour credit.

**Freshman Year**

| Course | Page | No. Course | Hours 1st Term | Hours 2d Term |
|---|---|---|---|---|
| Analytic Geometry and Calculus | 33 | 6 | 6 | 6 |
| Chemistry, Introductory Inorganic | 33 | Chem. 1 | 6 | 0 |
| Chemistry, Qualitative Analysis | 42* | " 7 | 0 | 6 |
| Physics | 38* | Phys. 2,7 | 5 | 3 |
| Crystallography | 58* | Geol. 12 | 0 | 3 |
| Military Drill | 34 | 1 | 1 | 1 |

**Sophomore Year**

| Course | Page | No. Course | Hours 1st Term | Hours 2d Term |
|---|---|---|---|---|
| Mechanics of Engineering | 38 | M5, 6 | 5 | 5 |
| Chemistry, Quantitative Analysis | 42* | Chem. 12 | 0 | 6 |
| Physics Laboratory | 33 | Phys. 14 | 4 | 0 |
| Mineralogy | 58* | Geol. 13 | 3 | 0 |
| Dynamic and Historic Geology | 57, 59* | " 1,21 | 3 | 3 |
| Drawing | 35 | D1, 2 | 3 | 3 |
| Forge Shop | 35 | S4 | 0 | 2 |

In addition to the above, three hours a week of either Military Drill or Physical Culture must be taken in the sophomore year.

**Junior Year**

| Course | Page | No. Course | Hours 1st Term | Hours 2d Term |
|---|---|---|---|---|
| Kinematics | 36 | D6 | 0 | 2 |
| Drawings | 35, 36 | D5, 7 | 3 | 3 |
| Hydraulics | 38 | M12 | 0 | 2 |
| Heat-Power Engineering | 39 | P10 | 3 | 3 |
| Metallurgy of Iron and Steel | 40 | X6 | 2 | 0 |
| General Econ. Geology | 60* | Geol. 32 | 3 | 3 |
| Mining of Mineral Deposits | 60* | " 34 | 3 | 3 |
| Surveying | | C.E. 10,11 | 3 | 4 |

During the summer following the junior year the student is required to devote about eight weeks to field work in Mining and Ore Dressing.

**Senior Year**

| Course | Page | No. Course | Hours 1st Term | Hours 2d Term |
|---|---|---|---|---|
| Assaying | 43* | Chem. 18 | 3 | 0 |
| Blowpipe Determination of Minerals | 58* | Geol. 14 | 1 | 0 |
| Machine Design— | | | | |
| (a) Drawing | 36 | D10 | 2 | 2 |
| (b) Lectures and Recitations | 36 | D16 | 3 | 3 |
| Mining Methods and Design | 38 | D39 | 2 | 2 |
| Mechanical Laboratory | 40 | X10, 11 | 3 | 3 |
| Examination of Mineral Deposits | 60* | Geol. 33 | 0 | 2 |
| Electrical Engineering | 42 | E14 | 2 | 2 |
| Electrical Engineering | 42 | E15 | 2 | 2 |
| Machine Work | 35 | S10 | 0 | 2 |
| Elective | | | 0 | 2 |

*These refer to pages in the Announcement of the College of Arts and Sciences, 1914–15, which may be had upon application to the Secretary of Cornell University, Ithaca, N. Y.

### 3. REGULAR FIVE YEAR COURSE

The requirements for admission to the five year course leading to the degree of Mechanical Engineer are given on page 16.

The optional hours in the five year course make it possible for the student either to elect subjects of a liberal or cultural value, or to specialize to a limited extent in some branch of science in which he may be particularly interested, such as Economics, Chemistry, Physics and Geology; or the student may include some of the elementary courses in Mining or Civil Engineering or in Architecture.

The outline of the first two years gives the subjects which must be taken in order that the student may enter the third year properly prepared for the engineering work. It is essential that the student should follow the sequence of subjects as given in this outline, for otherwise it may be impossible for him to complete the requirements for the degree by the end of the fifth year.*

NOTE. In referring to courses of instruction the following abbreviations are used: Shop, S; Machine Design, D; Mechanics of Engineering, M; Power Engineering, P; Experimental Engineering, X. For description of courses given in Sibley College see page 34; for description of courses given by other colleges, see the announcements of those colleges.

**First Year**

| Course | Page | No. Course | Hours 1st Term | Hours 2d Term |
|---|---|---|---|---|
| English | | 1 | 4 | 4 |
| Advanced Algebra | | 2 | 5 | 0 |
| Solid Geometry | | 1 | 0 | 3 |
| Trigonometry | | 3 | 0 | 3 |
| Chemistry | 33 | 1 | 0 | 6 |
| Engineering Principles | 35 | S2 | 1 | 0 |
| Forge Shop | 35 | S4 | 0 | 1 |
| Foundry | 35 | S3 | 2 | 0 |
| Elective in Arts and Sciences | | | 5 | 0 |

**Second Year**

| Course | Page | No. Course | Hours 1st Term | Hours 2d Term |
|---|---|---|---|---|
| Analytical Geometry and Calculus | 33 | 6 | 6 | 6 |
| Chemistry | 34 | 6 | 5 | 0 |
| Physics | 33 | 3 | 0 | 6 |
| Drawing | 35 | D1, 2 | 3 | 3 |
| Elective in Arts and Sciences | | | 3 | 2 |

*A student who meets the requirements for entrance to the college of Arts and Sciences, and who also receives credit for the 4 units of mathematics in Group *a* on page 15 may be able to secure the A.B. degree at the end of four years, and the M.E. degree at the end of the fifth year. During the first three years the student would be registered in the College of Arts and Sciences, but would pursue a course of studies approved by the Sibley College Adviser for five year students. The last two years would be spent in Sibley College.

**Third Year**

| Course | Page | No. Course | Hours 1st Term | Hours 2d Term |
|---|---|---|---|---|
| Mechanics of Engineering | 38 | M5, 6 | 5 | 5 |
| Physics Recitations | 33 | 8, 9 | 2 | 2 |
| Physics Laboratory | 33 | 14 | 2 | 2 |
| Kinematics | 36 | D6 | 0 | 2 |
| Drawing | 35, 36 | D5, 7 | 3 | 3 |
| Materials | 40 | X6 | 2 | 0 |
| Pattern Making | 35 | S7 | 0 | 3 |
| Elective in Arts | | | 3 | 0 |

**Fourth and Fifth Years**

The fourth and fifth years are identical with the third and fourth years of the regular four year course (see pages 25 to 28).

## 4. FIVE YEAR COURSE SPECIALIZING IN MINING ENGINEERING

The requirements for admission to the five year course are given on page 16. This five year course leads to the degree of Mechanical Engineer, and it is possible for those pursuing it to complete not only the subjects listed in the four year course relating to Mining Engineering but also to take substantially all of the additional subjects given in the regular four year course in Mechanical Engineering.

## 5. A SIX YEAR COURSE LEADING TO THE DEGREES OF A.B. AND M.E.

A student in the College of Arts and Sciences who has satisfied at least six terms of residence, no one of them under the provisions of paragraph (2) of the requirements for the A.B. degree, may with the permission of the faculties concerned be registered both in the College of Arts and Sciences and also in any other college of Cornell University. This provision enables a student who so desires, to obtain the degree of A.B. from the College of Arts and Sciences at the end of four years, and the degree of M.E. from Sibley College at the end of six years.* Advice and assistance in arranging such a course may be had by applying to the Dean of Sibley College and the Dean of the College of Arts and Sciences.

In order to make it possible to secure the M.E. degree at the end of the sixth year, the student must complete the freshman engineering subjects (page 24) before the beginning of his fourth year, and must complete the list of sophomore subjects (page 24) before the beginning of his fifth year.

*See footnote on p. 31 regarding the possibility, under certain conditions, of securing the two degrees in five years.

# COURSES OF INSTRUCTION

## SUBJECTS GIVEN IN THE COLLEGE OF ARTS AND SCIENCES*

6. **Analytic Geometry and Calculus.** Throughout the year, credit 6 hours each term. Twenty-four sections daily. Under the direction of Dr. CARVER.

3. **Introductory Experimental Physics.** Repeated in second term, credit six hours. Prerequisite courses Advanced Algebra and Trigonometry. Three lectures and three recitations a week. Lectures: Professors NICHOLS, MERRITT and SHEARER, and Assistant Professor GIBBS. Class-room work: Assistant Professor GIBBS and Messrs. MURDOCK, ANDERSON, BOWN, HOWES, MALLORY, REICH, ROGERS, SWISHER, THOMPSON and WEEKS.

Entrance Physics will not be accepted as an equivalent of this course.

8. **General Physics.** Theory. First term, credit two hours. Prerequisite courses Math. 6 and Phys. 3. Messrs. KING, BROWN, GERMANN, GIBSON, KNAPP, PIDGEON, and POWER. Two days as assigned, Rockefeller as assigned.

Textbook work in statics, dynamics, properties of matter, electrostatics, and magnetism. Two hours of course 14 must be taken in connection with course 8.

9. **General Physics.** Theory. Second term, credit two hours. Prerequisite course 8 and the first term of 14. Instructing staff as in course 8. Two days as assigned, Rockefeller as assigned.

Textbook work. A continuation of course 8. Current electricity, heat (including thermometry, expansion, calorimetry, radiation, and conduction, properties of vapors, and an introduction to the kinetic theory of gases), and thermodynamics. Two hours of course 14 must be taken with course 9.

14. **Physical Experiments.** Throughout the year, credit two hours a term. Must be accompanied by Phys. 8 and 9. Must be preceded either by Math. 6 and Phys. 3, or by Phys. 2 and 7 and 2 hours of Phys. 10. Assistant Professor RICHTMYER, and Messrs. BROWN, GERMANN, GIBSON, KING, KNAPP, PERKINS, and PIDGEON. Rockefeller 250–257 as assigned.

Physical measurements, properties of matter, mechanics, heat, light, sound, magnetism, and electricity; the adjustment and use of instruments of precision. Results and errors are carefully discussed. Two hours of course 14 must be taken with course 8 and two hours with course 9.

1. **Introductory Inorganic Chemistry.** Lectures, recitations, and laboratory. Second term, credit six hours.

1a. Lectures: M W F, 11, M W F, 12, Professor BROWNE and Mr. DAVIS. Morse 1.

1b. Recitations (one hour a week to be arranged), and laboratory (two 2½-hour periods per week as arranged). Professors DENNIS and BROWNE, Dr. WELSH, and Messrs. OVERMAN, GULICK, PARMELEE, WEISER, MACK, BENNETT, and HOVEY.

Entrance credit in chemistry does not carry with it University credit in course 1. If a student entering the University from a preparatory school desires credit in course 1 he must pass an examination set by the Department of Chemistry. This examination is held both in New York City and in Ithaca on the same day in September as the entrance examination. University credit in course 1 that is obtained by passing this examination does not carry with it entrance credit in chemistry.

Examinations for those who were unavoidably absent from the final examinations in course 1 will be held at 2 p. m. on the day before instruction begins in the fall.

---

*Only those subjects that are included in the regular four year course in Mechanical Engineering are given. For the other subjects see the Announcement of the College of Arts and Sciences.

6. **Qualitative and Quantitative Analysis.** Repeated in second term, credit five hours. Prerequisite course 1. Dr. LEMON, and Messrs. RAY, ELLEY, SMITH, DAVIS, BOHALL, MOODY, and THURSTON.

Lectures: T Th, 12, Morse L. R. 1.

Laboratory sections: M W F, 2–5; T Th S, 8–11; T Th S, 9–12.

Qualitative work: the properties and reactions of the common elements and acids and their detection in various liquid and solid mixtures.

Quantitative work: the preparation and use of volumetric solutions and work in elementary gravimetric analysis.

Examinations for those who were unavoidably absent from the final examination in course 6 will be held at 2 p. m., September 29, 1915.

52. **Elementary Economics.** Throughout the year; credit two hours a term. One lecture and one recitation each week. Lectures, M, 9; repeated T, 12. Assistant Professor TURNER.

1. **Military Training and Instruction as Infantry.** Required of all first year men. Throughout the year; credit one hour a term. M W F, 4:45, Armory. Practical Instruction: Outdoors in fair weather, three hours per week; indoors in winter months, one hour per week. Theoretical instruction: Winter months, two hours per week, covering Military Policy and Military History, the Value of Military Training to a man and the Nation, Infantry Drill Regulations, Theory of Target Practice, Camp Sanitation, Field Service Regulations, Personal Hygiene, Organization, Theory and Functions of Various Arms, Field Engineering, Guard Duty. Practical rifle practice on outdoor and indoor ranges required. Lieutenant BULL and assistants.

2. **Elective Military Training.** Throughout the year, credit two hours each term. Optionally substituted for Physical Training in second year by all students in four year and five year courses, and elective in upper class years. Prerequisite course 1. M W F, 4:45, Armory. An advanced course covering all phases of practical and theoretical work of the Infantry soldier in preparation for qualification for commission in the volunteer forces of the United States. Lieutenant BULL and Assistants.

3. **Military Science and Tactics.** Second term, credit two hours. T Th, 12, Goldwin Smith 124. An advanced lecture course in Military Science and Tactics. Lieutenant BULL.

4. **Band Music.** Practical and Theoretical instruction. Throughout the year, credit two hours each term. M W F, 4:45, Armory.

All instruments, music, etc., are furnished by the University free of cost to the student. The members constitute the University Band.

Open to all students who have made a satisfactory beginning with any of the customary band instruments. Properly qualified students may substitute this course for either the required military drill (course 1), or the required physical training. Mr. BRISSETTE.

## SUBJECTS GIVEN IN SIBLEY COLLEGE

About three hours in shops, laboratories, computation work, or drawing count as one credit hour in the schedule.

### Department of Machine Construction

S 2. **Engineering Principles.** Freshmen. Either term as assigned, credit one hour. Discussion of the elementary principles that underlie the development of energy from natural sources and its transmission and application to human needs. Professor SMITH.

S. 3. **Foundry Work.** Freshmen. Either term, credit two hours. Six hours of work a week. Moulding, core making, mixing, and casting of metals, use of moulding machines. Demonstration of large work and production in quantities. Messrs. VANDERHOEF and ———.

S. 4. **Forge Work.** Freshmen. Either term, credit one hour. Three hours of work a week. Forging, welding, tool dressing, tempering, etc., together with demonstrations in the production of drop forgings. Messrs. HEAD and BROOKS.

S. 7. **Pattern Making.** Sophomores. Either term, credit three hours. Nine hours of work a week. Prerequisite course S. 3. Use of hand and machine tools for wood working, followed by graded instruction in pattern making, construction of core boxes, etc. Messrs. HOOPER, BUSH, and ALLEN.

S. 10. **Machine Work.** Juniors. Throughout the year, two hours credit a term. Six hours of work a week. Prerequisite courses S. 3, 4, and 7. Use of measuring instruments, hand and machine tools, fitting, and assembling. Operation and use of jigs and other manufacturing fixtures. Operation of semi-automatic and automatic machines and the illustration of manufacturing methods generally. Assistant Professor WELLS, and Messrs. HOWE, BUCK, and MCLAUGHLIN.

### Department of Machine Design

D. 1. **Drawing.** Required of freshmen. First term, credit three hours. Nine hours of work a week. Lettering (proficiency in at least one style of simple lettering); mechanical drawing; working drawings, including conventions, standards, etc., following the best commercial practice. Assistant Professor HAM, and Messrs. ASHWORTH, EATON, MILLS, VAN DER DOES DE BYE, and WATERS.

D. 2. **Descriptive Geometry.** Required of freshmen. Second term, credit three hours. Nine hours of work a week. Lecture and drawing periods. The course includes points, lines, planes, solids, tangents, intersections, and developments, with solutions in all quadrants; isometric projections, with practical applications. Assistant Professor HAM and Instructors as in D 1.

D. 3. **Drawing.** For students registered for the degree of Bachelor of Chemistry. First term, credit three hours. Nine hours of drawing a week. Lettering, mechanical drawing, working drawings, including conventions, standards, etc. Similar to Course D. 1 but modified to suit the needs of students registered as above. Assistant Professor HAM and Messrs. MILLS and WATERS.

D. 5. **Machine Drawing.** Sophomores. First term, credit three hours. Nine hours of drawing a week. Prerequisite courses D. 1 and 2. Application of the work of course D. 1 to machine drawing in connection with empirical designing; proportioning of machine details as fixed by common practice rather than by mathematical theory; making and using standard data sheets; making of

assembly drawings. Assistant Professor HAYES and Messrs. BENNETT, BRADFORD, GARNER, and HUSSEY.

D. 6. **Kinematics.** Sophomores. Second term, credit two hours. Prerequisite courses D. 1 and 2, and must be taken with course D. 7. Two recitations a week on the theory of mechanisms, instant centers, cams, gears, linkages, velocity and acceleration diagrams, etc. Assistant Professor HAYES, and Messrs. BENNETT, BRADFORD, GARNER, and HUSSEY.

D. 7. **Kinematic Drawing.** Sophomores. Second term, credit three hours. Nine hours of drawing a week. Prerequisite courses D. 1 and 2, and must be taken with course D. 6. Drawing board application of the work in course D. 6. Solution of mechanisms by means of instant centers, the designing of cams, gears, linkages, etc., drawing of velocity and acceleration diagrams, etc. Assistant Professor HAYES, and Messrs. BENNETT, BRADFORD, GARNER, and HUSSEY.

D. 10. **Drawing and Design.** Juniors. Throughout the year, credit two hours each term. Six hours of drawing a week. Prerequisite courses D. 5, D. 6, D.7, M. 5 and 6, and must be taken with course D. 16. Drawing room problems in elementary machine design illustrating the work as given in D. 16. The student for the first time undertakes the design of a complete machine, laying out the general outlines, proportioning the details theoretically, and modifying his results by practical considerations. All computations necessary for the complete design must be carefully and systematically made. Working drawings of the most important details and a finished assembly drawing are completed. Professor KIMBALL, Assistant Professor ALBERT, and Messrs. BRADFORD, CORWIN, GRAHAM and ROGERS.

D. 16. **Machine Design.** Juniors. Throughout the year, credit three hours a term. One lecture and two recitations a week. Prerequisite courses D. 6, D. 7, M. 5 and 6, and must be taken with D. 10. Selection of mechanism for specified work and study of practical considerations involved. Analysis of energy and force problems in machines. Determination of driving devices as based on work to be done. Proportioning of detail parts as dictated by stress and practical considerations. Applications of the laws of mechanics and kinematics to the design of machines, and a discussion of empirical design and modifications due to practical considerations. Professor KIMBALL, Assistant Professor ALBERT, Messrs. BRADFORD, CORWIN, GRAHAM and ROGERS.

D. 22. **General Engineering Design.** Required of seniors in Option C. Throughout the year, credit three hours a term. Lectures. Prerequisite courses D. 10, D. 16, and P. 10, and must be taken with D. 23. For students who do not wish to specialize in any particular branch of engineering but wish to get a general knowledge of mechanical engineering design and construction. The work of the first term consists of a discussion of the problems met with in the design, construction, and equipment of mills, factories, etc., including foundations, walls, floors, trusses, roofs, and mill construction work in general; powering of factories, motor driving of machine tools, etc. In the second term this work is applied to the outline design of a complete power house, including the location of plant; track and wharf facilities; selecting and locating boilers and engines; coal storage, coal and ash handling equipment; selection and arrangement of condensers, pumps, steam piping, etc. Professor HESS, and Messrs. LEE and TOWNSEND.

D. 23. **Drawing and Design.** Nine hours of work a week throughout the year, credit three hours a term. Prerequisite courses D. 10 and 16 and P. 10, and may only be taken in connection with D. 22. Design and drawing of various classes of work illustrating the principles discussed in D. 22. Graphical analysis of stresses in trusses and other structures. In the second term, drawings are made for the complete outline design of a power house as discussed under course 22. Professor HESS, and Messrs. LEE, and TOWNSEND.

D. 24. **Engineering Notes.** Elective for seniors. Second term, credit two hours. Prerequisite courses D. 10 and 16. Lectures on some practical problems encountered in the everyday work of the engineer, solutions of these being arrived at by a reference to actual experience in different branches of engineering. Problems illustrative of the application, in combination, of the three qualifications of the successful engineer, *i.e.*, theory, practice and common-sense. Professor MCDERMOTT.

D. 25. **Ship Design.** Required of seniors in Option D. Lectures throughout the year, credit three hours a term. Prerequisite courses D. 10 and 16. The lectures of the first term deal with the conception and derivation of the elements of form; hydro-static principles underlying the design of vessels; methods of computing the geometrical quantities—displacement, centers of buoyancy, metacenters, etc.; tonnage, reserve buoyancy and freeboard; materials used in the construction of vessels; the structural elements of mercantile and naval ships, their functions and inter-relations; construction rules of the leading Classification Bureaus and Navy Departments.

The lectures of the second term deal with the weights, strength and stability of vessels and the methods which are used in practice in estimating these quantities and qualities. Safety of life at sea is given the fullest consideration. Professor MCDERMOTT.

D. 26. **Speed and Power of Ships.** Required of seniors in Option D. Second term, credit two hours. Prerequisites D. 10 and 16. Lectures. The fundamental hydro- and aero-dynamics underlying the study of the resistance of vessels—floating, submarine and aerial—and of the different propelling agents, chiefly that of the screw-propeller. An analytical discussion of the experiments made on models of ships and propellers in the experimental tanks and laboratories in the United States and abroad, and from the results obtained practical methods and formulas are derived for estimating the resistance and horse-power required for vessels of all types, as also, the most suitable dimensions of propeller. The different types of propelling machinery—steam (reciprocating and turbine), electrical, internal combustion, and their combinations; their mechanical, space and weight efficiencies; and their respective merits reviewed from the propulsive and commercial standpoints. Steam boilers of the firetube and watertube types; their characteristics and suitability for mercantile and war vessels. Professor MCDERMOTT.

D. 27. **Design and Drawing.** Required of seniors in Option D. Throughout the year, credit three hours a term. Must be accompanied by D. 25. Delineation of the "lines" of a vessel with selected elements of form. Drawing of "scantling" section according to the rules of the American Bureau of Shipping. Computations of geometrical quantities, strength and stability. Estimates of horse-power, weight of vessels and machinery. Professor MCDERMOTT.

D. 28. **Specifications, Contracts, etc.** Required of seniors in Option D. First term, credit two hours. Prerequisite courses D. 10 and 16. Lectures. Discussion of the headings and principal points to be observed in drawing up specifications and contracts for vessels, their equipment and machinery. Financial, technical and operative organization of shipyards. Cost systems and methods leading to efficient production. Professor McDERMOTT.

D. 39. **Mining Methods and Design.** Required of all seniors in mining; not open to others. Six hours per week throughout the year, credit two hours per term. Lectures, reading and drafting as assigned. The course includes the design of machinery for extracting and concentrating ores, the design of pumps, timbering, etc. Students in this course are divided into groups, each of which undertakes some comprehensive portion of the development of a mining property, while a seminar keeps these groups in touch with each other. Professor KIMBALL.

D. 40. **Advanced Designing.** For graduates who have had the equivalent of D. 22 and D. 23, or of D. 25, 26, and 27. Advanced work in original design as arranged with the head of the Department of Engineering Research and with Professors KIMBALL, McDERMOTT, and HESS.

### Department of Mechanics of Engineering

M. 5 and 6. **Mechanics of Engineering.** Sophomores. M. 5 in first term, M. 6 in second term. Credit five hours a term. Prerequisite course Mathematics 6. Theoretical and applied mechanics, including statics, kinetics, and mechanics of materials; resolution, composition, and equilibrium of forces; statics of rigid bodies, cords and structures; center of gravity and moment of inertia; composition and resolution of displacements, velocities and accelerations; Newton's law; fundamental equations of motion; rectilinear and curvilinear motion of a particle and of rigid bodies; motion diagrams; work, energy, and power, with application to machines; impact; friction; graphical statics of structures and mechanisms; stress and strain; strength and elastic properties of materials in tension, compression, and shearing; torsion; bending moment, safe loading, deflection and resilience in simple and continuous beams; non-prismatic beams; combined bending and torsion; eccentric loading; curved bars and hooks; columns; problems showing application of principles of mechanics in engineering design. Professor WOOD, Assistant Professors GARRETT and DAUGHERTY, and Messrs. CORNELL, DAY, FRANCIS, and PARMLEY.

M. 12. **Hydraulics.** Juniors. Second term, credit two hours. Prerequisite courses M. 5 and 6. Hydrostatics: pressures in containing vessels, centers of pressure, and flotation. Hydrokinetics: flow through orifices and over weirs; general equation of energy; losses of head; flow in pipes and open channels; and dynamic action of streams. Assistant Professor DAUGHERTY and Mr. FRANCIS.

M. 21. **Hydraulic Turbines.** Elective. First term, credit two hours. Prerequisite course M. 12. One lecture and one recitation a week. Theory, construction, and installation of modern hydraulic turbines, and a study of their characteristics with a view to intelligent selection of the proper type and size of turbine for any given set of conditions; costs of turbines and water power development. Assistant Professor DAUGHERTY.

### Department of Heat-Power Engineering

P. 10. **Elementary Heat-Power Engineering.** Required of all juniors. Throughout the year, credit three hours a term. Prerequisite courses Physics 8, 9, and 14, Chemistry 6, M. 5 and 6, and D. 5, 6, and 7. Two recitations and one lecture a week throughout the year. Thermodynamics of gases and vapors, theoretical cycles and general theory of heat engines; application to steam engines; practical modifications in real engines; engine efficiencies and performance; the indicator card as a measure of work and basis for design; economic features,—reduction of losses by jacketing, superheating, compounding, etc.; application of unaflow and locomobile principles; valves and valve gears; types of engines; governors. On account of the importance of a thorough understanding of this subject, the student is required to solve a large number of problems in the class room. Assistant Professor ELLENWOOD, and Messrs. CLARK and JONES.

P. 11. **Heat Engines and Auxiliaries.** Required of C.E. seniors. Second term only, credit three hours. Not open to Sibley students. Prerequisite courses Physics 2 and 7, (or the equivalent), Chemistry 1, C.E. 20. One lecture and two recitations a week. Elementary consideration of behavior of gases. Gas engines. Theory of vaporization. Study of boilers, types of boilers; advantages and disadvantages of various types. Action of vapors in cylinders. Steam engines and turbines; parts and operation; types, advantages and disadvantages; application; steam consumption and efficiencies. Advantages of condensing; types of condensers; condenser pumps; condenser auxiliaries,—cooling towers, ponds, etc. Pumps. Contractors' plants. Cost of power.

This course is recommended for all students who wish to obtain a general elementary knowledge of heat-power engineering without great technical detail. Assistant Professor ELLENWOOD, and Messrs. CLARK and JONES.

P. 20. **Power Plant Design.** Required of all regular seniors. Throughout the year, credit three hours per term. Prerequisite course P. 10. One lecture and two recitations a week. A continuation of course P. 10.

Steam turbines; internal combustion engines; fuels; principles of combustion; boiler furnaces and grates; heating surfaces of boilers; types of boilers; natural and forced draft; producers; principles governing the transfer of heat; feed water heaters; economizers; superheaters; theory of condensation; types of condensers; condenser pumps; cooling towers and similar devices; water treating apparatus, filters, separators, and similar auxiliary apparatus; flow of steam and gas; refrigerating machinery, and air compressors; elementary theory, types and efficiencies.

Consideration of selection of elements and their combination in power plants, with the object of producing the maximum profit from investment and operation. Professor SMITH, Assistant Professor MATTHEWS and Mr. BERRY.

P. 23. **Heat-Power Machinery Design.** Required of seniors in Option B, and not open to others. Throughout the year, credit three hours a term. Prerequisite courses D. 10, D. 16 and P. 10, and must be accompanied by course P. 24. Discussion of types, arrangements, general properties and details of steam and internal combustion engines and their auxiliaries. Power plants. Professors BARNARD and HIRSHFELD and Mr. PEIRCE.

P. 24. **Designing and Drawing.** Required of seniors in Option B, and not open to others. Throughout the year, credit two hours a term. Prerequisite courses D. 10, D. 16 and P. 10 and must be accompanied by P. 23. Two drawing periods per week. The practical solution of problems discussed in P. 23. Professors BARNARD and HIRSHFELD and Mr. PEIRCE.

P. 25. **Steam Turbines.** Senior elective. Second term, credit two hours. Prerequisite course P. 10. Two lectures a week. Classification of turbines and description of leading features of the various types. Mechanical and thermal considerations underlying the action of steam in turbines. Calculations involved in turbine design. Discussion of building, erecting, and testing. Adaptability to special conditions of service. Economic results of the use of turbines in engineering practice. Professor BARNARD.

P. 28. **Gas Manufacture and Distribution (General).** Seniors. First term, credit two hours. Prerequisite courses D. 10, D. 16, and P. 10. Two lectures a week. The theoretical and practical principles governing the production and handling of all industrial gases. Professor HIRSHFELD and MR. PEIRCE.

P. 29. **Gas Power Machinery (General).** Seniors. Second term, credit two hours. Not open to students taking Option B. Prerequisite courses D. 10, D. 16, and P. 10. Two lectures a week. General theory and salient points in the design and operation of internal combustion engines and gas producers. Description of existing commercial types, study of relative advantages, and consideration of questions of economy. Professor HIRSHFELD and Mr. PEIRCE.

P. 30. **Steam Boiler Design.** Seniors. First term, credit two hours. Prerequisite courses D. 10, D. 16, and P. 10. Lectures on fuels, combustion, types of boilers, general proportions, materials, design of boiler details, settings, stokers, accessories, and the equipment and arrangement of boiler plants. Professor BARNARD.

P. 40. **Advanced Heat-Power Engineering.** Elective for those who have completed the equivalent of the design subjects in senior Option B. Work and credit as arranged with the head of the Department of Engineering Research and with Professors SMITH, BARNARD, and HIRSHFELD.

### Department of Experimental Engineering

X. 6. **Manufacture of Engineering Materials.** Required of sophomores. First term, credit two hours. Prerequisite course Chemistry 1. Two lectures a week. Metallurgy of iron and steel, copper, etc. Professor DIEDERICHS.

X. 10. **Mechanical Laboratory—Properties of Engineering Materials.** Juniors. First term, credit three hours. Prerequisite courses X. 6, M. 5 and 6. One laboratory period a week. Mechanical strength of materials, tension, torsion, transverse, and compression tests; the variation of the mechanical strength with differences in composition or heat treatment; demonstration of different methods of tempering, annealing, forging, etc. The student is required to write and submit one report each week upon the experiment of the previous week. Professor DIEDERICHS, Assistant Professor UPTON, and Messrs. DIEDERICHS, DIX, GIBSON, KLINK, and THATCHER.

X. 11. **Mechanical Laboratory—Introductory Experimental Engineering.** Juniors. Second term, credit three hours. Prerequisite courses M. 5 and 6, Chem.

6, Phys. 3. One laboratory period a week as assigned, one written report a week. Calibration of indicator springs, steam gauges, thermometers, and dynamometers; practice and tests of various computing machines; viscosity and friction tests of lubricants on various testing machines; tests of heating values of coals; steam quality tests, with various forms of calorimeters; measurement of water; efficiency test of steam engines and pumps, feed water heaters, and condensers. Reports are required and these must include all the data and results of the various tests. together with conclusions. The preparation of the report is considered an important part of the laboratory course. Professor DIEDERICHS, Assistant Professor UPTON, and Messrs. DIEDERICHS, DIX, GIBSON, KLINK, and THATCHER.

X. 12. **Mechanical Laboratory.** For students in Chemical course. Second term only, credit four hours. Prerequisite courses M. 5, and Phys. 10 and 14. One laboratory period (Sat. 8–12) and one report per week. Principal tests on materials of construction; use, adjustment and calibration of common engineering instruments; testing of oils; engine and boiler trials; study of refrigeration, etc. Professor DIEDERICHS, Assistant Professor GAGE and Messrs. DAVIS, HOOK, LANDT and THOMAS.

X. 20. **Mechanical Laboratory—Experimental Engineering.** Seniors. First term, credit three hours. Prerequisite courses X. 10, 11, P. 10. One laboratory period a week. Efficiency tests of gas and gasoline engines, steam injectors, steam turbine, blowing fan, hydraulic turbine and centrifugal pump; flue gas analysis, etc.

Reports are required to be full and complete, to include data and results of each test under consideration, and all information necessary to understand completely the machine tested and the methods used. Professor DIEDERICHS, Assistant Professor GAGE, and Messrs. DAVIS, HOOK, LANDT and THOMAS.

X. 21. **Mechanical Laboratory—General Experimental Engineering.** Required of seniors. Second term, credit three hours. One laboratory period a week alternating with one computing period. Written report required on each experiment. Detailed study of methods of testing and methods of computation in the following subjects: testing of engines and boilers, air compressors, ice machines; measurement of flow of water, etc.

Concerning reports see last paragraph under X. 20. Professor DIEDERICHS, Assistant Professor GAGE, and Messrs. DAVIS, HOOK, LANDT and THOMAS.

### Department of Electrical Engineering

E. 12. **Essentials of Electrical Engineering.** Required of seniors in the civil engineering and chemistry courses. First term only, credit four hours. Two recitations and one laboratory experiment with report each week. The purpose of the course is fourfold: (1) to review and emphasize the fundamental physical principles applied in electrical engineering; (2) to familiarize the student with and give practice in the handling of electrical machinery; (3) to enable the student to choose the proper type of apparatus for any particular service demanded in ordinary elementary practice; (4) to enable the student to read intelligently electrical engineering literature. Messrs. H. W. BROWN and PAGE.

E. 14. **Elementary Electrical Engineering.** Required of all juniors in the regular course, and of seniors in mining. Throughout the year, credit two hours per term. Prerequisite courses Physics 8, 9, and 14 M. 5 and 6. Must be accompanied by E. 15. One lecture and one computing period a week during the first term; direct current circuits and machinery. One recitation and one computing period per week during the second term; alternating current circuits and machinery. Professor KARAPETOFF, Messrs. BIERMA, C. G. BROWN, DEANS and STEVENS.

E. 15. **Elementary Electrical Engineering.** Required of all juniors in the regular course, and of seniors in mining. Throughout the year, credit two hours per term. Prerequisite courses Physics 8, 9 and 14, M. 5 and 6. Must be accompanied by E. 14. Two recitations per week during the first term; direct current circuits and machinery. One laboratory experiment and one report per week during the second term; operation of electrical machinery. Professor KARAPETOFF, Assistant Professor FORD, and Messrs. BIERMA, C. G. BROWN, DEANS, PAGE and STEVENS.

E. 20. **Theory of Electrical Machinery.** Required of seniors in Option A. Throughout the year, credit two hours a term. Prerequisite courses E. 14 and 15. Two lectures a week. First term covers chiefly the laws of the electric and the magnetic circuits; representation of alternating currents by vectors and by complex quantities; the nature and effects of inductance, capacity, and iron loss; theory of transmission lines and transformers. Second term is devoted to the theory of transmission lines, transformers, generators, motors, and rotary converters. The lectures are as far as possible correlated with the work in course E. 21. Professor KARAPETOFF.

E. 21. **Characteristics of Electrical Machinery.** Required of seniors in Option A. Throughout the year, credit four hours a term. Prerequisite courses E. 14 and 15. Two recitations and two computing periods a week. Problems on the work covered by course E. 20; in particular, performance characteristics and elementary design of transmission lines, transformers, induction motors, alternators, synchronous motors and converters, and direct-current generators and motors. Professor KARAPETOFF, and Messrs. PERTSCH and TAPPAN.

E. 22. **Design of Electrical Machinery.** Elective for seniors in electrical engineering. Second term only, credit two hours. Prerequisite courses first term of E. 20 and E. 21. One recitation and one computation period a week. Principles of commercial design of electrical machinery. The topics vary from year to year in accordance with the predominant interests of the class and the progress of the art. The following topics have been treated in a few preceding years:

(1) General data; deduction of principal formulæ used in designing direct and alternating current machinery and transformers; empirical, electrical, and mechanical data. (2) Commercial requirements; cost of manufacturing; requirements of service; guarantees. (3) Deduction of design data from tests on existing machines. (4) Elementary design with given principal dimensions. (5) Selection of principal dimensions for a complete line of similar machines. (6) Mechanical design and preparation of shop drawings. (7) Transient electrical phenomena. Professor KARAPETOFF and Mr. ———. [Not given in 1915–16.]

E. 23a. **Generation of Electrical Energy.** Elective for seniors in electrical engineering. First term only, credit two hours. Prerequisite courses E. 14, E. 15 and X. 11. One recitation and one computing period a week. (a) A consideration of the modern central station for the generation of electrical energy, particular attention being paid to the electrical equipment and its selection. (b) A study of the problems encountered in the design and operation of central stations. Assistant Professor FORD.

E. 23b. **Transmission of Electrical Energy.** Elective for seniors in electrical engineering. Second term only, credit two hours. Prerequisite courses first term of E. 20 and E. 21. One recitation and one computing period a week. A study of the theory underlying the operation of the transmission line, together with some problems illustrating the more important points in its design and construction. Assistant Professor FORD.

E. 25. **Elements of Electric Railway Practice.** Elective for seniors. Second term only, credit two hours. Prerequisite courses E. 14 and 15. One recitation and one computing period a week. Apparatus and construction involved in a modern railway system, including car equipment, trucks, motors, controllers, bodies, accessories, overhead construction, third rail, conduit, and other topics of similar character. The underlying idea is to show the application of the general laws of electricity to this particular branch. Some attention is devoted to the relation of electric railways to the public and to finance. Mr. CHAMBERLAIN.

E. 27. **Wireless Telegraphy and Telephony.** Elective for seniors in electrical engineering. Second term only, two hours credit. Two recitations a week. Prerequisite courses first term of E. 20, E. 21, and E. 28. Fundamental principles involved in wireless telegraphy and telephony, and study of the development of the application of these principles up to the present status of the art. Mr. BALLARD.

E. 28. **Senior Electrical Laboratory.** Required of seniors in electrical engineering. Throughout the year, credit four hours a term. Prerequisite courses X. 11, E. 14 and 15. Two laboratory periods, one recitation, and one report a week. The work during the first term includes the following simple experiments selected from the most important branches of electrical engineering: tests of integrating wattmeters; arc lamps and series arc lighting; electrical relations in transmission lines; characteristics of direct-current generators and motors; commercial tests of transformers; load tests on alternators and induction motors; assemblying switchboards, wiring controllers; telephone work, etc. During the second term more advanced experiments are conducted, such as performance tests of transmission lines, transformers, alternators, and induction motors, commercial tests on magnetic qualities of steel and iron; tests of special alternating-current instruments; separation of losses in generators and motors; electrical relations in polyphase systems; operation of rotary converters; electric railway experiments; determination of A. C. wave-form; regulation of storage batteries. Assistant Professor FORD, and Messrs. CHAMBERLAIN, CATLIN, and BALLARD.

E. 30. **Engineering Mathematics.** Elective. Open to seniors and graduate students only. Throughout the year, credit two hours per term. Two recitations a week and home work. General methods by which problems are expressed in mathematical form, studied to establish a better understanding of the unity between the instruction in pure mathematics and the various engineering courses.

It is aimed to prepare the student better for engineering research and for the study of advanced engineering literature. The fundamental physical and mathematical assumptions are critically reviewed, and the limitations in the results pointed out. Methods are indicated for obtaining approximate solutions, establishing empirical formulæ, and solving problems by the use of tables, charts, and mechanical devices. The course consists of problems taken in different years from mechanical, civil, and electrical engineering, involving analytic geometry and the elements of differential and integral calculus. The topic for 1915–16 will be the mathematical theory of propagation of electric waves and oscillations along conductors, as applied to the transmission of power and intelligence.

E. 33. **Special Electrical Engineering Problems.** First or second term, or both. One to three hours. Open to juniors and seniors. Investigations, construction, design and testing of electrical apparatus. The number of students that can be accommodated will depend upon the available opportunities and facilities. Professor KARAPETOFF, Assistant Professor FORD, and Mr. PERTSCH.

E. 34. **Current Topics in Electrical Engineering.** Second term only, two hours credit. Two recitations a week. Reports and discussions on noteworthy articles in current electrical literature. The purpose of the course is to familiarize the student with the timely topics discussed in the principal periodicals and transactions relating to electrical engineering. Mr. CATLIN.

E. 35. **Electrical Engineering for M.E. Seniors.** Required of Sibley seniors who take Options B to E, inclusive. Throughout the year, two hours credit per term. Prerequisite courses X. 11, E. 14 and E. 15. Laboratory work, problems and reports. The course is arranged for the needs of mechanical engineers, particular attention being paid to the operating features of electrical machinery, and to selection of proper electrical apparatus for power and industrial purposes. Assistant Professor FORD, Messrs. BALLARD, CATLIN, CHAMBERLAIN, HUBBARD, and STEVENSON.

[NOTE. For other electrical and illumination courses see under Physics in the Announcement of Courses in the College of Arts and Sciences.]

### Department of Industrial Engineering

I. 11. **Industrial Organization.** Required of all juniors in Sibley College and not open to freshmen or sophomores. Open to juniors and seniors of other colleges. First term, credit two hours. A course of lectures on modern industrial tendencies and the principles that underlie modern methods of production. The treatment includes not only the reasons for our changed methods of production but also discussion of the principal features of such industrial factors as factory legislation, factory welfare work, and modern methods of administration. Professor KIMBALL.

I. 20. **Industrial Administration.** Required of all seniors in Option E. Elective for seniors pursuing other options. Two lectures per week throughout the year, credit two hours per term. Prerequisite course I. 11. A discussion of modern time-keeping and cost-finding systems, methods of planning work and of insuring production, administrative reports, time and motion study, purchasing, etc. Plant location and arrangement, heating, lighting and powering of plants. Professor KIMBALL and Assistant Professor WELLS.

I. 22. **Drawing and Design.** Required of all seniors in Option E. One recitation and six hours in the drawing room per week throughout the year, credit three hours per term. Prerequisite courses D. 10 and D. 16, and must be accompanied by I. 20.

The work of the first term consists of graphical constructions and their application to administrative problems; graphic planning of organization and the creation of blanks and other administrative documents. In this term each student is required to make a complete outline of the organization of some industrial enterprise either from assumed data or for some plant with which he is familiar.

The work of the second term consists largely of exercises in the location and arrangement of industrial plants from the standpoint of economic production. Each student is required to locate geographically and arrange the plant for which he has made an organization outline in the work of the first term. Professor KIMBALL and Mr. ———.

I. 23. **Safety Engineering and Fire Protection.** Required of all seniors in Option E. May be elected by seniors pursuing other options. Two lectures per week during the second term, two hours credit. Prerequisite course I. 11. A discussion of modern factory construction from the standpoint of fire protection and also of safety appliances in connection with factory equipment. Assistant Professor WELLS.

I. 40. **Advanced Industrial Engineering.** Open to graduates and seniors who have completed the equivalent of I. 20 and 22. Professor KIMBALL and Assistant Professor WELLS.

### Department of Engineering Research

R. 22. **Engineering Research.** Elective. Either term, credit one hour for forty hours of actual work. Open to a limited number of seniors and graduates who have shown proficiency in engineering research. Commercial tests and special problems, which may be carried on in any department of the College, but are under the general supervision of this department. Professor CARPENTER, Assistant Professor SAWDON, and Mr. MCVETTY.

R. 23. **Power Plant Testing.** Elective. Either term, credit one hour for forty hours of actual work. Open to a limited number of seniors who have shown proficiency in engineering research. Testing of complete power plants as occasion offers. Registration arranged for when opportunities occur. Notices of opportunities will be posted on the Department bulletin board. Professor CARPENTER, Assistant Professor SAWDON, and Mr. MCVETTY.

R. 24. **Motor Car Construction.** Elective. Seniors and graduates. Second term, credit one hour. Two lectures a week, illustrated by lantern slides showing the structure and development of the motor car. Professor CARPENTER.

R. 25. **Heating and Ventilating.** Elective. Seniors and graduates. Second term, credit two hours. Lectures and recitations covering the methods of design and of construction of various forms of ventilating and heating apparatus. Professor CARPENTER.

R. 27. **Thesis.** Senior elective. Either or both terms, maximum total credit eight hours. The work on which the thesis is based must be original investigation. All theses are under the general supervision of the Department of Engineering Research. The thesis may be a theoretical investigation, a design

experimental work, or other research and may be conducted under the guidance of members of any department of the College, but subject to the general supervision of this department. All students who are considering the preparation of a thesis should consult the head of this department during the junior year if possible. A bound copy of the thesis, in the original typewriting (not a carbon copy) on paper 8 x 10½ inches in size must be deposited before May 15th at the Dean's office, with the approval of the professor in charge of the investigation. This copy becomes the property of the University, and is filed in the General Library where it becomes accessible for reference. Professor CARPENTER, Assistant Professor SAWDON, and Mr. MCVETTY.

OFFICIAL PUBLICATIONS OF CORNELL UNIVERSITY

Issued at Ithaca, New York, monthly from July to November inclusive, and semi-monthly from December to June inclusive.

[Entered as second-class matter, August 31, 1910, at the post office at Ithaca, New York, under the Act of July 16, 1894.]

These publications include

The Annual Register (for the year 1914–15, published January 15, 1915), price 50 cents.

Catalogue Number for 1913–14 (containing lists of officers and students), price 25 cents.

Book of Views, price 25 cents.

Directory of Faculty and Students, Second Term, 1914–15, price 10 cents, and the following informational publications, any one of which will be sent gratis and post-free on request. The date of the last edition of each publication is given after the title.

General Circular of Information for Prospective Students, January 1, 1915.

Announcement of the College of Arts and Sciences, May 1, 1914.

Announcement of Sibley College of Mechanical Engineering and the Mechanic Arts, February 1, 1915.

Announcement of the College of Civil Engineering, February 15, 1914.

Announcement of the College of Law, July 1, 1914.

Announcement of the College of Architecture, May 15, 1914.

Announcement of the New York State College of Agriculture, June 1, 1914.

Announcement of the Winter Courses in the College of Agriculture, June 15, 1914.

Announcement of the Department of Forestry, August 1, 1914.

Announcement of the Summer Term in Agriculture, April 15, 1914.

Announcement of the New York State Veterinary College, April 1, 1914.

Announcement of the Graduate School, January 15, 1914.

Announcement of the Summer Session, March 15, 1914.

Annual Report of the President, October 1, 1914.

Pamphlets on prizes, samples of entrance and scholarship examination papers, special departmental announcements, etc.

Announcement of the Medical College may be procured by writing to the Cornell University Medical College, Ithaca, N. Y.

Correspondence concerning the publications of the University should be addressed to

The Secretary of Cornell University,
Ithaca, New York.